HINTS

ARBORICULTURE

IN THE

PUNJAB:

INTENDED FOR THE USE OF

DISTRICT AND FOREST OFFICERS.

BY

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	Plants	Specific gravity	Centesimal yield
Indrojub seed oil	Wrightia antidysenterica	—	10
Linseed oil	Linum usitatissimum	0·9347	27
Marking nut oil, kernel	Semecarpus anacardium	—	7
" crust	Ditto ditto	—	5
Mustard seed oil	Sinapis nigra	0·9160	33
Myrabolan oil	Terminalia chebula	—	2
Nahor oil	Mesua ferrea	—	—
Neem seed oil	Azadirachta indica	—	10
Oleander seed oil	Nerium thevetia	—	5
Orange seed oil	Citrus aurantium	—	17
Pesta oil	————	—	40
Physic nut oil	Jatropha purgans	—	30
Poppy oil	Papaver somniferum	0·9243	50
Radish seed oil, or Moola seed oil	Raphanus sativus	0·9187	13*
Safflower oil	Carthamus tinctorius	—	—
Soap berry oil	Sapindus emarginatus	—	—
Sunflower seed oil	Helianthus annuus, et perennis	0·9262	10
Tea seed oil	Thea veridis et bohea	—	—
Teel oil	Sessamum orientale	0·9253	40
Thistle oil	Argemone maxicana	—	—
Tobacco seed oil	Nicotiana, tabacum	0·9232	—
Turnip seed oil	————	—	20

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INTRODUCTION.

THE following pages form a portion of a work which I intend to publish in the shape of Pamphlets for the use of untrained Forest Officers.

The Pamphlet on Arboriculture, which is here presented to the reader, is divided into four chapters. The first three chapters contain the general rules on *artificial cultivation*, *natural reproduction*, and *treatment of forests and single trees*. The fourth chapter shows how these rules are to be applied to the *cultivation, reproduction, and treatment of the trees most commonly cultivated in the Punjab*.

I trust that the hints contained in this Pamphlet may prove of use to the District Officers, in whose behalf it has been published.

ARBORICULTURE.

Creation, Reproduction and Treatment of Forests.

THE creation or reproduction of a forest, by means of sowing or planting, is called *artificial cultivation.*

The forest may depend for its reproduction on the seed shed by mature trees, or on the power of coppicing from the stool of utilized trees. This is called *natural reproduction.*

The fostering and guidance of the growth of trees by means of thinning, pruning, &c, &c, is termed *treatment of forests.*

HINTS

ON

ARBORICULTURE IN THE PUNJAB.

CHAPTER I.

Artificial Cultivation.

Definition of the term "Artificial Cultivation."

ARTIFICIAL cultivation includes all cultivation by means of sowing, planting and cuttings.

Necessity of Artificial Cultivation.

It is necessary to have recourse to artificial cultivation on places where a forest has to be created; on blanks; on extensive clear cuttings; in forests where the ground is covered with a dense growth of grass or weeds; on places which are likely to be flooded, or where soil and climate are too dry to give small seedlings a fair chance; on small blanks, and as an aid to natural reproduction. Also for district arboriculture; on roads; along canals; around wells; in fields; and on grazing grounds.

Advisability of Artificial Cultivation.

Artificial reproduction being by far the most certain to succeed is preferable (in many cases other than those already enumerated) to natural reproduction, which depends on various external influences.

Work preparatory to Artificial Cultivation.

When it is necessary to have recourse to artificial cultivation, it will be found that in a few rare cases only the ground is fit for it without preparatory works, such as artificial irrigation, drainage, working up of the soil, and, as regards nurseries, even preparation of artificial manure.

Artificial Irrigation.

In the Panjáb, artificial irrigation is of special interest to the Forester. On the Bár, where we possess the largest amount of available land, neither the moisture in the soil, nor the natural rain-fall is sufficient for arboriculture, and only by means of canals are we enabled to raise forests of any other kind than the small and slow-growing indigenous rakh trees and shrubs.

Recommending the Rúrki Treatise on irrigation for special study, I here only add a few remarks on the subject.

We distinguish between *rájbahas*, or chief feeders, *distributive channels* and *trenches*. The first receive the water from the canal by means of a water-head or mogah; the distribution channels convey the water to the different points of the area to be irrigated, and the trenches bring the water within actual reach of the seedlings or plants. The width and depth of the ditches depend, of course, on the area. The rájbahas, which have to feed many compartments, are the largest, and may have 12 and 14 feet upper width. The distribution channels, which have to supply one compartment only, are much smaller, and the trenches are only one foot deep by one foot wide. In loam, the larger ditches must have sloping sides of about one foot to one foot. In sandy loam, or sand, the slope must be made more gradient. In fact, the looser the soil, the more gradient must the slope be. The first point to be considered in a system of irrigation is the equal fall in the channels, so as to prevent silting up of water-courses and destruction of embankments.

With us, the amount of fall depends mostly on the fall in the canal and the height of the weirs from which we receive the water. Wherever we have had to resort to artificial watering, it was found advisable to procure the highest possible average fall, but it would not be judicious to have a fall of more than 1 to 1½ feet in a 1,000 feet. The ditches should have the same cross cut; and to secure this, a so-called profile pattern should be made of light wood to serve as a guidance to the workmen employed in digging the ditches It will, at the same time, facilitate

the measuring up of the work. The excavated earth from the larger ditches is to be divided on both sides of the water-courses, and the soil out of the trenches is to be formed into a ridge on the sunny side of the trench The water will reach by the capillary action to the very top of the ridges. This system of irrigation requires to be kept up by the annual removal of the silt and vegetation collected in the water-courses and trenches.

Drainage.

Though we have as yet had no opportunity in this country of cultivating boggy or marshy soil, it is as well to add a few remarks concerning it The system and formation of ditches for the complete drainage of such a soil is the same as that employed for irrigation, though they aim at opposite results.

The smallest ditches draw the superfluous water from the soil within their immediate vicinity, the larger ditches collect the water, and the head-channel or channels lead it into the nearest river, canal or other natural drainage This system is to be adopted if the boggy condition of the soil is due to a collection of rain water which cannot percolate through the ground on account of the nature of the soil, nor run off, owing to the peculiar formation of the surface.

Springs without natural outlets are often the cause of the marshy condition of the soil. When this is the case, the most sensible plan will be to lead them by means of a short water-course into the nearest natural drainage. It is, of course, necessary to keep all drains as free as possible of silt and vegetation till the trees have closed above

When once a cover of trees has formed, the danger of the soil getting boggy again has passed away. A good forest is as active a means of drainage as a system of ditches.

It will be advisable to lay two of the smaller drainage ditches close together, and to form a ridge for cultivation between the two

Preparation of Soil

The ground being thus, according to circumstances, either irrigated or drained, the next point to observe will be

the preparation of the soil. Forests under perfect, natural conditions require no preparation of soil whatsoever.

The leaves shed by mature trees and the decaying wood form a vegetable mould, and therewith a natural seed bed. The soil is loosened through the influence of the humus The seed germinates readily, and the loose soil not only affords well-decomposed nourishment to the young seedlings, but the roots are able to penetrate it without effort. But, as remarked above, this perfect state of soil is but rarely attainable on places selected for artificial cultivation. On some spots, humus soil has never been formed, on others it has disappeared through long exposure, or the soil is covered with dense weeds and grass. In such cases the Forester must endeavour to imitate nature as accurately as possible, and create the conditions necessary to the growth of plants by means of the preparation of the ground.

Of importance are, the *covering of the soil; the upper layer for germinating of the seed, and the lower space for the formation of roots.*

Covering of the ground.

The covering of the ground may be either beneficial or hurtful to cultivation according to the nature of the covering and soil. A light growth of weed on sand and limestone soil is beneficial,—such a covering as will spring up shortly after the clear cutting of a good forest. A covering of weeds on a heavy loam and clay soil is extremely pernicious on account of its quick and dense growth.

A most destructive covering of the ground in the plains is "Saccharum" (see Nág, Changa Manga, Compartment No. 75, and Rodeshah).

The density of the growth not only smothers the young plants, but causes the stagnation of water, impedes a free circulation of air, and forms a sour humus,—all three detrimental even to trees that have topped the grass. They cause the decomposition of the sap, and thus kill the tree. (See Introduction "Diseases of Plants.")

On loamy soil the covering must be dug out by the root and burned. On sandy soil a partial thinning out and burning during the dry weather will be sufficient.

A still greater enemy to the young seedlings is "Salsola" (see Changa Manga, Compartment No. 6). It smothers and kills the young trees, and the only way to protect them is *to dig out the Salsola before it seeds and destroy it with* its roots.

When the ground is covered with Tamarix (Jau) a total cutting and partial clearing out of the roots will be sufficient.

Thickets of Calaminthus and Indigofera are very detrimental, but a cutting and partial clearing is all that is necessary.

A dense grass covering has to be cleared entirely if the soil is to be sown; but it is better to have recourse to planting on such places.

A fresh covering of Calaminthus, Indigofera, Raspberries, &c, and a thin growth of grasses, necessitate no removal if the soil can be seen everywhere, but an immediate cultivation is required here.

A covering of Ferns, Polygonum, Impatiens, &c, which has sprung up in the shade of a forest, and which remains for some time after clear cutting, indicates a soil ready for reception. They need not be removed, as they will disappear of their own accord. This is the best time to cultivate before more dangerous weeds have taken possession of the ground.

On steep slopes, the removal of weeds and other covering should be partial only.

Surface Soil.

The seed once enabled to come into close contact with the surface soil germinates, if healthy, under the influence *of moisture and heat, without any reference to the quality* of the soil. The power of germinating and of forming an embryo plant lies within the seed.

Lower Soil.

As soon as the plants form roots, their further growth and well-being make it needful that the roots should be able to penetrate the lower parts of the soil and find properly-decomposed nourishment there.

Each kind of soil requires a treatment of its own. A preparation beneficial to one species of soil would have exactly the opposite effect on another. The preparation of the soil may consist in a slight turning up of the surface only with hoe or plough, or a deep digging and working.

I will begin with the strong binding loam of our Bár land. Experience has shown us that the deeper the preparations are on this soil, the more satisfactory the results will be.

As an exemplification thereof, I would point to the quick growth of trees along embankments, in canal and railway cuttings, and on a hundred other places where the soil has been well turned. A prolonged exposure of the dug-out soil to the influence of the air before cultivation is of great benefit, but irrigation must be avoided, as a dense covering of weeds and grasses would invariably spring up, which, on heavy soil, is always detrimental to the young plants.

A poor and dry soil requires also a deep working; but the light sandy loam and sandy soils of our sailaba land want only a slight digging.

All preparation of soils on hill sides should be as shallow as possible, and here the greatest care must be taken that the good soil is not carried off by the water. The ground must, under any circumstances, be only partially freed of weeds, and worked in such a manner that the water percolates *through*, but does not flow *over*, the prepared parts This can only be effected by giving the prepared places a horizontal position, sloping slightly towards the hill side.

Preparation of the entire area.

Only in few cases is it necessary to prepare the soil of the entire area.

A total preparation is *imperative*:—

1. For *seed* and *planting* nurseries, which have to be thoroughly dug up and prepared as carefully as a garden.

2. Where the worst description of weeds cover the whole area.

3. When the ground is used for agricultural purposes during the tree cultivation.

Preparation of a portion of the Area

In all other cases a partial preparation is preferable. It is not only a saving of money, labor, time and seed, but it has proved to be the safer method of cultivation.

We distinguish the following preparations of soil:—

1. Ridges.
2. Trenches.
3. Strips.
4. Plots
5. Small seed plots and holes.
6. Scooped-out, hollow places

1 Ridge Cultivation.

This way of preparing the soil is only practicable on irrigated or drained land The irrigation or drainage trenches are made close together (average 10 feet), and the earth thrown up on the sunny side of the trenches is formed into a ridge and beaten down or allowed to settle (The entire area of the Changa Manga Plantation has been treated in this way)

2 Trench Cultivation

This system was formerly in vogue in the Punjab Plantations. The trenches were dug, the earth removed and filled in again When the soil is hard and poor, and especially when it is covered with weeds, this method, undoubtedly, answers well, but the ridge system offers the same advantages, even to a higher degree, and at the same time facilitates watering. The trench system can therefore only be recommended in cases of roadside planting on hard soil, or where it is necessary to break through a layer of *kankar or of clay* impenetrable to roots *In such cases,* the good soil only is thrown back into the trenches or holes

It is well to leave the earth taken out of the trenches exposed to the influence of the climate for a whole season. This will greatly loosen and help to dissolve the soil.

3 Cultivation in Strips

In the plains, the strips should, like the trenches and ridges, run in straight parallel lines, leaving the refuse on

the sunny side. In the hills, the lines should be parallel and horizontal, and the refuse placed on the side nearest the slope.

The width and distance of the strips depend on—

1.—The covering of the ground, and existing or expected grass and weed growth.

2.—The moisture of the soil.

3.—The growth of the species of wood to be cultivated

4.—The amount of seed and money available.

The width may be that of a single plough line, or the breadth of a single hoe, if the soil is light and the covering slight, especially if the trees to be cultivated court protection. The width of the strip must be extended to 1 and 1½ foot if the soil contains much moisture, and if the growth of grass and weeds is considerable, and if the seedlings require much light. If the soil improves in quality, gets better, fresher, more binding, and if the covering becomes stronger, the width has to be increased in the same proportion, and may be extended to 3 feet and more. The distance of the strips generally corresponds with their width. Thus the broader the strips, the further apart they may be made.

The *depth* of the strips depends on the kind of soil, as noted under the heading "Preparation of Soil;" but the species of wood to be cultivated regulate to a certain degree the depth of the digging. We adopted this method for the cultivation of the Shaderah Plantation in 1870-71, and at Kálatop in 1871-72.

Rules for the preparation of Strips.

Much care must be taken when the upper covering of weeds is removed, not to lose the better soil which lies mostly close below the surface. Only in case of sour humus this layer has to be removed.

The sub-soil is the next object to be considered. There will be no occasion to turn it up if it is loose enough to allow the roots to penetrate easily. When the soil is very loose, a deep working would only accelerate the drying up of the soil. If, on the contrary, the ground be hard and binding, or so full of roots that they form an impenetrable

layer, the soil must be worked well and deep In this case, too, a season's exposure to the influence of the climate improves the soil. This is, however, impracticable with some of the light and dry soils in our plains, as the dust-storms, as well as severe rains, carry the best surface soil away. The work may be done with either hoe or plough.

4. Cultivation of Plots.

This cultivation is nearly the same as the cultivation of strips. *Size, depth, and distance* of the plots, depend on the same conditions. The working is exactly the same. When it is found impracticable to dig out the roots and stumps of old trees, and where stones or rocks would interfere with the regularity of strips, or on sandy sailába between saccharum bushes, which it is unadvisable to dig out, this system is generally resorted to.

The plot cultivation affords one or two advantages which may be enumerated here. When a selection of plots is made, it is always possible to choose spots covered with excellent soil When places have to be selected on a hill side, spots may be secured well sheltered by roots and stones and where humus has collected, or where the formation of the ground affords protection to the young seedlings Very wet soil is unsuitable to this kind of cultivation, as the water collects and remains on the selected spots. Another drawback is the difficulty of regular sowing, so that no places may be omitted.

5. Cultivation of small Seed Plots and Holes.

This is the cheapest cultivation on sailába land with light covering. The holes are made only one foot square, and the sub-soil is turned with a hoe. A satisfactory result has been obtained by this system of cultivation at Shaderah and Sádhanwáli Plantations with Sissú, Kikar, Jhand, &c.

In hill forests, this method can only be adopted shortly after clear cuttings, before the ground is covered with the more dangerous kinds of weeds.

On light sailába, the heavier species of seeds, such as Ber, and even Kikar seeds, which demand a thicker covering

of soil, can be sown in a still less expensive manner by pressing a small hole in the soil and dropping the seed into it, and closing the hole by stamping or pressing upon it. This method would also answer for sowing oak seeds in hill forests.

6 *Cultivation of scooped-out, hollow places.*

This method has not been tried as yet in this country, but it has attained great success in some of the European mountain forests in places where neither seed-sowing nor planting succeeded before. One-third of a strip, such as I have described before, is dug up, and the soil formed into a ridge close to the khad. Thus three chances are given to the seed to grow—either on the strip, on the hollowed, or on the raised portion.—*(See Fig. 1)*

After a few years' trial, the Forester will be able to ascertain which of the three conditions suits each species of tree, and can act upon this experience. I may, however, remark here that this method is regarded as a kind of "*Testimonium Paupertatis*" on the part of the Forester, as it entails a certain waste of money, caused by his ignorance as to the exact requirements of the trees he is called upon to cultivate. Still it has succeeded, and should be tried in this country, where we have so little experience.

Preparation of Artificial Manure.

After the seedlings have germinated in nurseries, it is of great importance to accelerate their development, in order to help them over the dangers of the first period of their lives, and also to economize time. Manuring, as we know by experience, is the best and quickest way to effect this The natural manure for such nurseries is, of course, good decomposed forest humus; but as it is seldom obtainable unmixed with seeds of weeds, burned manure is more frequently used.

The way to prepare the ash manure is very simple Dry, freely burning wood is collected and heaped up, intermixed and covered with dried grass, leaves, humus and sods in form of a kiln The burning must go on as slowly as possible. Preparing the manure in autumn and cover-

ing it through the winter with earth increases its quality. The action of the fire frees the mineral nutriments contained in the burning substances, which afterwards afford sustenance to the plants, besides destroying the superfluous acid in the soil, and loosening the binding earth When the soil contains heavy binding clay, it is advisable to dig up, in autumn, part of the surface soil, mix it with the manure, and with it form small heaps over the entire area. The influence of the climate will loosen the clay, amalgamate the substances well, and the work will repay itself next spring in the shape of a more vigorous growth of the plants.

Collection and preservation of Seed.

All seeds must be collected when perfectly ripe; but as in many instances it is easier to collect the seed on the trees before it is shed, it is necessary to watch the progress of ripening Care must also be taken to collect it from *mature* and *healthy* trees, as they alone yield really vigorous and productive seed. The soil affects not only the parent tree, but also the seed. It cannot therefore be expected that the seed of a stunted or misshapen tree will produce healthy and vigorous plants

The seed must be collected during fine, dry weather and in the middle of the day. Only thoroughly dry seed will keep sound; wet seed will get heated and ferment. The above simple rules ought to be strictly adhered to when collecting the seed. The preservation is more difficult. The best way to preserve every kind of seed is to sow it quickly; but should this be impossible, the chief means of preservation are judicious drying and protection against moisture, heat, and frost. Seeds containing a large amount of water or oils are difficult to preserve, even for a short time.

According to the different species of trees, there are various signs to indicate the ripeness of the seed. Some trees, such as the deodar, oak, &c., shed their seeds; with others the husk gets woody, as with the Pinus longifolia, &c. The fulness of the grain, the healthy colour, and the weight, are external indications that the seed has attained maturity. But even should the seed have been ripe and

good at the time of gathering, a careless or faulty treatment may afterwards destroy the germinating power. Seeds received from merchants, contractors, or from other sources, should always be tested before used, however healthy the grains may appear. The easiest, quickest, but not quite reliable, test is to put some of the seed on a red hot iron plate. If the grain retains still the germinating power, it will burst. The more reliable tests take a little more time. The seed is put either into pots with loose, moist soil, or between moist flannel. Both flannel and earth must be kept moist in warm places. The percentage of germinating grains will serve as a criterion as to the germinating power of the rest.

Seeds, especially those of pine trees, though they loose in merchntile value by being mixed with the husks, will keep longer if not separated from them, and they will keep longest of all if left in the cones. All seeds must be carefully guarded against the ravages of mice, rats, birds, &c, as they either eat, carry away, or defile it.

Different species of seed require various degrees of dryness, but a constant renewal of air is imperative. If this precaution be neglected, the seed gets mildewed, and will be hopelessly spoiled. This is the chief drawback against preserving in holes under ground. Provided the seed is turned and mildew prevented, moisture alone is not so greatly to be apprehended as is generally supposed. In long dry seasons it is even necessary to moisten the seed to prevent its being dried up entirely. The best place in which to keep seed is a shed with a boarded or kankared floor, and with a sufficient number of air holes. Seed should not be heaped up too thickly, and, especially immediately after being gathered, must be turned daily. Seeds containing a great amount of oils had better be turned twice daily To ensure a quick germinating of imported seed, it is advisable to soften it in water, slightly mixed with muriatic acid. The mixture when tested with the litmus paper must impart to it a *light* claret colour only. Another way is to steep the seed for some days in lime water. This is especially to be recommended when the seed is old.

General remarks on Sowing, Planting, Cutting, Grafting and Budding

Before entering on the cultivation of the specific Punjab trees, I would make some general remarks on the actual sowing, planting, cutting, grafting and budding of trees The first consideration is always whether to sow or plant, and this is often a hotly-contested question Though I shall return to this point when we come to consider each kind of tree separately, I would here point out some general rules to guide us in the selection of a method.

It is necessary to have recourse—

To Sowing·

1. *In the open*, such species of trees as do not suffer much during their first youth from either frost or weeds, or such as out-grow speedily all danger.
2. Species of trees which suffer from transplanting.
3. When seed is cheap.
4. If the soil is light, and not inclined to be covered with a jangle of weeds.
5. In a mild climate and in shady places
6. Where there is no danger to be apprehended from birds and insects.
7. *Under cover*, for mature trees in a year when natural seed fall has failed.

The worst soils for sowings are clay and lime soil When the soil is clay, it is hardly possible to sow without artificial irrigation, especially if the species to be cultivated do not strike at once deep roots. Sailaba is the best soil for sowings.

To Planting.

1. Where a strong cover of weeds prevents or endangers the sowings.
2. On wet, stony, or poor soil
3. On clay and lime-stone soil
4. On steep slopes.
5. On south slopes.
6. In a rough climate.
7. To replenish sowings
8. When plants are tender during their youth.
9. If seed is difficult to procure or expensive.
10. If time is of great value, as for winter cultivation on irrigated land.
11. If the soil is used for cotton or other agricultural purposes.
12. If a certain degree of moisture is wanted.
13. On roadsides and for well plantations.

Way of Sowing.

The sowing is, under all circumstances, most effectually done with the hand.

Broadcast sowing should be executed like the sowing of grain, and in case of light seed during calm weather only. Great care must be taken to fill all strips and seed places with good seed, so that half a dozen vigorous grains may lie close together.

Covering of Seed

The covering with earth is the next step to be considered The amount of covering depends entirely on the seed and soil. Small and light seed requires but a thin covering, and the tenth part of an inch is sufficient, especially if the soil is heavy. Often a light covering of moss or leaves is enough. Larger seed may be put half to one inch deep under ground, and in loose or loosened soil the larger seed will germinate if covered with two inches of earth. A deep covering may prove injurious if the soil is very binding, as it is apt to form a crust under the influence of rain or floods In such cases, as well as with lighter grained seed, a simple mixing of the seed with the upper loosened soil will be sufficient.

The manner and means by which the seed is covered vary with the depth of the sowing One of the best ways for deeper covering is to rake the soil over with the hoe or rake The lighter covering is easily done by dragging weighted bushes lightly over the surface. Of greater importance is the pressing down of the soil after sowing. If the soil is either naturally loose, or has been thoroughly worked up, care must be taken to press it down after sowing, as this will prevent the damaging influence of the rain, which might otherwise wash the seed out of the ground or carry it too deeply down. A well beaten-down soil will keep moisture for a long time in the ground, and the roots of the young plants will acquire a firmer hold.

If a mixed cultivation of trees is contemplated by means of sowing, it is better to sow each species separately, as the seeds may require different thickness of soil covering

Amount of Seed.

The amount of seed to be sown depends on soil and species, and also on the soundness of the seed. If the soil and seed are good and the cultivation small, and if it is possible to expend much care on the preparation of the soil, as well as on the sowing, a much smaller amount of seed will be needed than if the soil is uncongenial, or if the covering of weeds endanger the seedlings, or if the seed is doubtful or unclean, or if the great extent of the cultivation

makes it difficult to attend carefully to the preparation of the soil and the sowing.

A greater amount of seed will be wanted if it is intended to plant out the sowings, as in such case a more dense growth is desirable. The relative amount of seed wanted depends much on the tendencies of the trees; some prefer air in their youth, and an open growth, while others flourish close together. Again, the size of the seed has much to do with the amount The quantity required per acre for the different methods of cultivation will be noted further on

Execution of Sowing

The sowing itself must be executed by daily labor and under strict supervision, though the preparation of soil may well be done by contract I would, in many cases, however, prefer daily labor for the preparation of soil, that is, if the places for cultivation have to be selected, and when the final work offers difficulties in the shape of measurements at the time of taking over If mixed sowings are to be made, it is advisable to give the different workmen each a different species of seed, and to make them sow per acre in the proportion of the mixture required This will produce a more equal mixture of trees in the new forest than when the seed is mixed up in bags at the time of sowing, and the different requirements of each species of seed can be better attended to. If the workmen are not all skilled laborers, the work should be taken in hand by a small gang only, to be gradually increased as the men learn their work until the entire gang is employed

Period of Sowing

We have three periods of sowing,—spring, rains and autumn.

Spring Sowing.

Spring sowings succeed in the hills, but in the plains only with the aid of artificial watering Rain sowings,

as successful in the plains as they are in the hills, though not with every species of trees. We have recourse to autumn sowing in the hills, and on sailába land in the south-east of the province, especially where floods endanger the rain sowings.

Autumn Sowing.

In high altitudes,—such as Kálatop, Kúlú, Pangi, &c, &c,—autumn sowings are the most natural, because the transition from winter to summer is very abrupt

A greater degree of safety is ensured to autumn sowings if the cultivation happens to be on protected ground, under standard trees, or amongst high weeds. The difficulty of preserving easily heated seed is thus avoided, but mice and rats are more dangerous to autumn than to spring sowings

Trees which exhibit a tendency to suffer from frost during their first growth must not be sown in autumn

In the plains, autumn sowings must be executed in September, so that the plant germinates within the same year, but they succeed only in places where the winter frosts are not severe, or do not exist at all

Rain Sowing.

The rain sowings are the great stand-by on all sailába lands, and succeed, of course, on irrigated land. In the lower hills, up to 5,000 feet, where the dry heat of May and June kills the spring sowings, and where the ground uncovered by snow is too cold for autumn sowings, rain sowings ought always to be used in preference.

Much care must be taken with regard to the replenishing of the sowings, and the Forester has to examine all new cultivations, and note all blanks which he was unable to replenish during the year of cultivation Before another new cultivation is undertaken, all repairs, carefully executed, must be completed.

Planting.

Planting is the most important and most difficult part of artificial cultivation As a rule, the cultivation with trans-

plants succeeds best if the conditions under which the young plants have previously vegetated are disturbed and altered as little as possible.

The Healthy Plant

The first object of our care is the plant itself Whether it has grown naturally in the forest, or has been reared artificially in nurseries, it must be *thoroughly* healthy The chief characteristics of a healthy plant are regular and well-developed roots and branches in just proportions They must also have a good amount of side branches The skin of the roots must be of a healthy color, and if the upper skin is removed, a moist and greenish-white skin must be found underneath it The bark of the plant itself must be smooth and devoid of parasites. The color of the leaves must be healthy and green, and the buds, if nipped off, must have a fresh and green appearance in spring

Greater care has to be taken in the selection of coniferous plants than in that of deciduous trees, the former not having the same power of reproduction It is a great mistake to disregard the health or even shape of plants Those that have suffered through cattle or frost should not be used for transplants, nor such as show by the withering away of small particles, that either the soil, climate, or the protection and treatment under which they have been reared, has disagreed with them Plants of a slender and weedy appearance, caused by the pressure of dense growth or weeds, ought not to be used at all, and plants reared under certain conditions must not be transplanted on spots which offer quite opposite conditions

The Nursery Plant.

The plants reared in nurseries are the most useful, especially for open positions.

The Natural Plant.

The selection of seedlings grown in the forest is exceedingly difficult, and must be done with great discretion Only

plants that have grown on open places should be selected. Their roots will be found sufficiently developed, and the plant itself strong enough to endure exposure.

Age and Size of Plants.

Age and size are next to be taken into consideration. The young and small seedlings can be dug up without getting much injured during the process, and as the cost of their transport is but trifling, a general rule has been adopted to transplant as early as possible. This rule, however, is greatly modified by the surroundings and the object of the cultivation. The species of seedlings, and the danger by flooding to which they may be exposed, must also be considered.

Other Points to be regarded in Transplanting

Next follow the digging-up of the seedlings, the transport, the excavation of holes, the transplanting itself, the pruning of branches and roots, the different methods of planting, and the distance and disposition of plants. The artificial rearing of plants forms a chapter by itself.

The Taking-Out of Plants

In digging up transplants, it is of the greatest moment to preserve, as much as possible, all the roots undamaged. The best way therefore is to dig up the seedling with a lump of earth round it. This cannot be done, however, on sandy or stony soil. The plants thus taken up cannot be transported very far on account of the cost. The older the seedling, the greater the care required in transplanting. Quite young plants, especially those of deciduous character, can be pulled up with the hand if the soil is light and moist, but all older plants and all pine trees should be carefully dug up with the spade or hoe. The removal of single plants from amongst the natural young growth of a forest is more difficult, more expensive in the long run, and less safe than rearing the plants in a nursery, and afterwards transporting them to the place of cultivation.

I give a list of some excellent instruments for digging up plants. The first is the circular spade *(see Fig. 2)*, which is to be recommended for loamy humus soil clear of stones and roots. It consists of an iron spade forming a hollow cylinder, one quarter open, and slightly converging towards the lower part The diameter of the cylinder is from 5 to 9 inches, and the length from 6 to 12 inches. The open sides are steeled and sharpened The stock, which has an iron foot-board for pressing, is about 3 feet high, and the wooden handle for turning the spade round is of nearly the same length. The plant is placed in the middle of the cylinder, the spade is pressed down, turned round, and the plant and earth lifted out in form of a flower pot The holes for planting can be made with the same instrument Another useful implement is the hollow spade *(see Fig. 3)* It is pressed into the ground first on one side, and then on the other side of the plant, and the earth containing the roots is lifted in the form of a cone Both these instruments are only useful when the plants are 1½ to 2 feet high If the plants are smaller still, the hollow spade, with a short handle, can be recommended, especially for digging up small pine seedlings in the forest. The common spade must be used to dig up larger seedlings, or to get plants out of a hard or clay soil. The *native khúrpa* is an excellent, though slow-working, planting implement for a hard soil *(see Fig. 4)*. A heavy iron spade with iron handle is useful on stony ground. It may also be recommended for transplanting large seedlings, as it does not damage the roots much. The upper breadth of this spade is 10 inches by ½ inch thick; the lower breadth is 6 to 7 inches, and the length of the blade up to 18 inches.

Transport of Plants

Every precaution must be taken during the process of transplantation. The seedlings must be guarded against every species of damage; but, above all, special care must be taken to prevent the drying-up of the roots. Small plants, whether transplanted with or without earth, should always be carried by men in baskets, or on stretchers, if the distance is not too great If small plants witho

earth have to be transported to a great distance, it is well to dip the roots into liquid mud made by mixing loam and water, and cover them with wet moss. Moss should also be stuck between the stems, and the whole tied into bundles, which should be moistened from time to time Such bundles, if carefully packed, can be sent by cart or rail Larger seedlings with earth round the roots may be transported on carts by putting them upright, or slanting with the tops towards the back of the cart. Under all circumstances, the spaces between the young seedlings should be filled up with loose earth or moss, so as to prevent, as much as possible, the soil being shaken off Very large seedlings for avenues can be transported with earth round them, but it becomes necessary then to cover the earth with matting securely tied round it.

Protection of Plants before Planting

The plants on arrival at the place of cultivation must be kept in a shady spot, and, if not used immediately, must be covered with loose earth, and moistened with water.

Plant Holes.

Before the seedlings can be put in, the plant holes must be first prepared. The size of the holes depends, of course, on the roots of the seedlings, and also on the relative goodness of the soil. On a poor hard soil the planting holes have to be made larger than on good soil Much care has to be taken when making holes not to throw aside or bury the better soil The surface cover and weeds must be carefully removed, but not so as to displace the surface humus. The upper soil should be well worked and mixed with the lower soil, though without unnecessarily removing it. If the young trees, and consequently the holes, are large, it is well to keep the humus soil separate, so as to bring it close to the lower roots The holes can be made either with the spade, the circular spade, the hoe, or the *khúrpa*. The cheapest and quickest way is to dig holes with the circular spade, provided the soil admits of its use. The cultivation will be much benefited if the holes are

made during the preceding season, as the salts in the raw soil will oxidise by this exposure to the influences of the air

Pruning of Plants

Our next consideration must be whether the plant is to be pruned, or not, before being put in its new place The general rule, that any kind of damage inflicted on the plant lessens the chances of success and interrupts the vegetation, leads us to look upon every pruning not only as unnecessary, but as injurious Seedlings transplanted with the earth round them should never be pruned, and pine plants under no circumstances, as the resin closes up the pruning-cuts and obstructs the circulation of the water The root of good-sized seedlings of deciduous trees may be pruned with advantage; but the damaged portions only should be cut off, and disproportionately long roots shortened The pruning should be done with a sharp knife, so as to inflict the smallest possible wound The roots, which are the organs of reception, being thus cut, and the balance between them and the branches, which are the organs of utilization, disturbed, means must be taken to re-establish that balance, and this is accomplished by pruning the branches They must be pruned from below, so as to prevent dew or rain-water collecting on the wound

PLANTING

Whether the plants are pruned or not, the next step is the actual planting.

Planting with Earth

The simplest and safest way is to plant with the earth round the seedlings, and in many instances this will also be found the cheapest way. There was a time when it was deemed impossible in Europe to transplant the Pinus Sylvestris (the same erroneous idea exists here with regard to the Kikar), but this popular delusion has passed away; for at present great areas of Pinus Sylvestris are transplanted with the earth, and if they are from 1 to 2 years old without it

The following are the advantages of planting with earth:—

1. All damages connected with the digging-up, transport, and planting are avoided
2. The roots remain in the same position, and the surrounding soil to which they are accustomed is retained
3. The plants are able to resist more effectually the influence of climate, especially frost and drought
4. The planting itself is done more rapidly and cheaply.
5. Any unskilled laborer can execute it.

The only care to be taken when planting with earth consists in filling up with loose soil the crevices between the lower portion, the sides of the holes, and the earth around the plants This must be especially attended to if some of the earth has got detached from the ball round the plant

Planting without Earth

Planting without earth presents more difficulties, and when the more delicate species of seedlings have to be transplanted, much care is required, and the work can only be done by experienced men. When larger plants for road-sides, &c, &c, are to be transplanted, it even becomes necessary to observe the same direction of the compass, and it is then advisable to mark the north side before digging up the plant, and to transplant it in the same position.

I proceed to describe the most approved way of planting seedlings without earth

A heap of good earth is placed in the centre of the hole, and the plant is put in in such a way that the stem stands right in the middle of it. The plant is then kept in an upright position with the left hand, and with the right hand the roots are placed in the most natural position; and carefully surrounded with good earth. The seedling is then slightly shaken with the left hand, and the earth manipulated with the right, so as to fill up the small crevices between the roots, and when this is accomplished, the rest of the hole must be filled up with the residue of

the soil Great care must be taken to keep the plant in an upright position. The hole being filled up, the earth is lightly stamped down round it with the foot, but this should be done very gently, and not close to the stem, or much harm may be inflicted by compressing or injuring the roots

Depth of Planting

As a rule, all seedlings should be transplanted without changing the conditions under which they were raised, and they must therefore be planted as deeply as they were previously growing But much more danger is to be apprehended from deep, than from shallow planting, especially as regards pine trees; for when the roots are withdrawn from the influence of the air, they sicken and die The stock should be placed a little above ground, so that the upper roots are only just covered with earth. The depth is, however, slightly modified by the soil and climate In case the soil is dry, and has not the power of retaining water, the plants must be put in deeper, and may even be planted in a hollow. But when the soil is wet, the seedlings must be planted in a shallow position, or, better perhaps, on raised ground On a constantly moist soil, or when it is overgrown with grass, it becomes imperative to plant on raised ground. The process is very simple.

In a circle of 2 to 3 feet, the grass is taken up with the sod, turned and covered with good soil on which the seedling is planted. Another way is to make little heaps one foot in diameter, and cover them with turned grass sods after the seedlings have been planted thereon. This is an excellent way on shallow binding soil, with little humus and much grass. On very poor or very stony soil it is advisable to surround the roots of the plants with a manure of richer soil, which may either be got from the adjacent forest or be prepared. By these simple, but rather expensive means, the safety and rapidity of the growth is insured.

Further Protection of Plants

The residue of soil and sods from the plant hole is usually laid round the plants with the grass side towards

the earth. When the plants are small, it is well to heap the refuse on the south side, as it will protect the stock from the direct rays of the sun. Dense weeds should be removed from the immediate vicinity of the young small plants. A good plan is to dip the roots into a mixture of water and loam immediately before planting. If water is to be had close by, the seedlings should be watered during the process of planting. By these means the roots are brought into closer contact with all the particles of earth, and the plants receive moisture at the same time. This is especially to be recommended for large plants on dry soil, but must be avoided for autumn planting in positions exposed to early and severe frosts.

Support and Fencing.

Supporting and fencing plants is only necessary on road-sides and where grazing grounds have to be planted.

Planting of Small Seedlings

If yearlings or very small plants are to be transplanted without earth into the forest, it is not necessary to make holes with a spade or hoe. The simplest method is with a wooden peg and mallet, or with the planting iron (*Fig.* 5 will explain the instrument.) The iron is driven into the soil with one hand and drawn out, the small plant is put into the hole with the other hand, and the iron is again rammed into the ground at a distance of 1 to 2 inches from the first hole, and the soil is pressed sideways on the plant. The second hole is closed up in the same way. The soil should be soft, and not much overgrown with weeds, otherwise it must be prepared beforehand. The broad side of the ordinary pickaxe may also be used, and the weeds removed with it at the same time.

Adding Humus.

If the soil is very poor, it is always advisable to improve it with some good humus or manure

Planting of Several Plants in the Same Hole.

This kind of planting is executed in exactly the same way, with the exception that a *bundle* of plants is put into a plant hole instead of a single one. Though preference should be given to single planting, yet there are instances when the last-named method may be recommended—on exposed positions, in high mountains, for safety belts against snow and avalanches. But there is no doubt that the plants thus raised develope their roots only in one direction, and are unable to resist storms and other inclemencies of the weather as effectually as single plants.

Planting with Artificial Manure.

Finally, a more scientific method should be noted here I mean the planting with artificial manure on very poor or stony soil. The preparation of grass ashes has already been discussed in a former chapter. The hole is made in the shape of a *Liltah*, the loose soil is removed from its centre, and a handful of ashes is pressed against one side of the hole The plant is then placed against the ashes, and more ashes, pressed on the other side The earth is now put back into the hole, and the same precaution must be observed as with ordinary single planting, so as to keep the best soil nearest to the plant. This method, though costly, repays itself in a rough climate and on very poor soil which has lost all the decomposed nourishment it once possessed, either through long exposure, or having been used as a grazing ground.

Distance and Form of Planting.

The distance and form of planting are the last points under discussion The distance depends—

1 On position and soil.
2 Size of plants
3 Peculiarities of the plants.
4 On the object of the cultivation.

In a dry climate and on a dry poor soil, especially in this country, it is necessary to plant close; also on places

where weeds are apt to spring up and suffocate the young plants. In the first instance, the ground must be shaded as quickly as possible, and the soil protected against the direct influence of the sun. In the second instance, the weeds must be kept down A mild, moist climate, and a rich and moist soil, admit of seedlings being planted further apart. Large plants, or plants of trees which outgrow rapidly the danger of weeds, may be planted further apart, but trees which have an inclination to grow bushy must be planted close together to check this propensity, and with a view to improve their growth. Small plants and seedlings of slow-growing trees require a closer planting, because they take a longer time to close overhead.

I proceed to enumerate several drawbacks connected with the system of planting far apart: the soil remaining uncovered for too long a period is liable to dry up and lose its nourishing power; and trees which close late overhead are apt to degenerate and grow into branches, and will yield not only less straight, but actually a smaller quantity of wood. The disadvange of close planting consists, *à priori*, in the greater cost of the cultivation, and secondly, in the want of growing space for each plant. Much of the vitality of the plants is lost in the struggle for light and air. Much again depends on the object of the cultivation. If it is contemplated to force the plants up to high-trunked timber trees, it is advisable to plant close, so as to obtain a quick closing overhead. This, however, is not of the same importance when purely fuel plantations are contemplated. If it is intended to plant on grazing grounds, where arboriculture is only a secondary consideration, the trees are planted at considerable intervals; also on road-sides, and even more so if it is contemplated to use the land on which the trees stand permanently for agricultural purposes. Little or no importance is attached to this point in an European country, where such considerations do not fall within the province of the Forester; but in this country, where the inhabitants pay no heed to the advantage of preserving trees on their own land, the District arboriculture falls to the duty of either the District Officers or

the Forest Department. If it is intended to create or reproduce a forest, the distance of planting should be between 4 and 10 feet, according to circumstances; for road-side from 10 to 30 feet, and on grazing grounds the distance may be even greater.

Form of Planting.

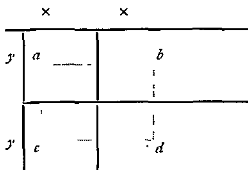
The distribution of plants over the area, though often under-rated, is of some importance. A regular distribution ensures the young plants the exact amount of growing space they require, and the necessary amount of light and air. Parallel lines are most frequently used in planting. The distance between the lines must be uniform; but the space between the plants in the lines is less than the distance between the lines. The planting in quincunces, squares, or triangles, is only a modification of this method.

The planting in lines has its advantages and disadvantages, of which the former in most cases outbalance the latter. Instead of plant holes, ditches may be drawn, which facilitate the irrigation or drainage, make the planting easier, and yield a greater amount of loose soil; the utilization of grass is easier, and the cultivation of cotton, &c, between the lines is much facilitated. The thinnings also can be taken in hand earlier, which will lead ultimately to greater regularity in the distribution of trees in the future forest.

A drawback to this method should, however, be here mentioned; the plants, during the first stage of their growth, do not develope their roots and branches with regularity on all sides, and therefore do not at first spring up in the same uniform manner as when the more equidistant methods are used.

The cost of cultivation depends much on the quantity of plants, and I subjoin the number of plants required per acre for the different forms and distances most in vogue:—

Line planting.



a = Area, n = number of trees
x = Distances between plants
y = Distance between lines

$$n = \frac{a}{x \times y}$$

Distance between lines	Distance between plants.											
	1	2	3	4	5	6	7	8	9	10	11	12
1	43,560											
2	21,780	10,890										
3	14,520	7,260	4,840									
4	10,890	5,445	3,630	2,722								
5	8,712	4,356	2,904	2,178	1,743							
6	7,260	3,630	2,420	1,815	1,452	1,210						
7	6,223	3,112	2,075	1,556	1,245	1,038	889					
8	5,445	2,722	1,815	1,362	1,089	908	778	681				
9	4,840	2,420	1,614	1,210	979	807	691	605	538			
10	4,356	2,178	1,452	1,089	871	726	622	544	473	430		
11	3,960	1,980	1,320	990	792	660	566	495	440	396	360	
12	3,630	1,815	1,210	908	726	605	518	454	403	363	330	303

The numbers of seedlings for planting in squares are under-lined, and some more given below for the planting of grazing ground.

$15^2=193$	$30^2=48$	$45^2=21$
$20^2=109$	$35^2=32$	$50^2=517$
$25^2=69$	$40^2=27$	

The amount of plants required for quincunx is exactly the same as for planting in squares, the distance between the plants is measured diagonally

For triangular planting the number of plants is $n=\frac{\text{Area}}{X^2\ 0\ 866}$.

For distances from 3 to 12 feet per acre

3=5,588	7=1,026	10=503
4=3,143	8= 786	11=415
5=2,012	9= 621	12=349
6=1,397		

Artificial Rearing of Planting Material.

The next point is the rearing of planting material (*see Fig.* 6)

Even plants reared in the forest, to be ultimately transplanted, gain by a previous treatment. All round the stem, at a distance proportionate to the size of the plant, the roots are cut off with a sharp iron spade, and the tap-roots shortened by means of a judicious dig of the spade. The earth is then well stamped down again. This is done two years previous to transplanting. The plant will sicken for a short time, but the wound will heal quickly, and close to the cicatrice a bundle of small roots will sprout out, so that when the tree is ultimately removed, its after-growth can be more securely counted upon. A judicious pruning of the large branches should accompany the cutting of the roots This process has the same aim as the transplanting in nurseries, namely, that it produces the largest amount of roots which are capable of receiving nutritious substances within the smallest possible space. The rearing of good planting material in nurseries is quite an art in itself, and should form one of the most careful studies Plants may be either transplanted at once into the forest from nurseries in which they have been reared

from seed, or be transplanted once or twice within the nursery before being ready for use. In the former case the nursery is called a sowing nursery.

Sowing Nurseries.

The first question when laying out a sowing nursery is its *position* and *nature of soil.* The general principle to guide us in our selection is this: the soil and position of the nursery should resemble, as much as possible, the area about to be cultivated. We should therefore endeavour to select an average soil, neither the best, nor a poor place. This principle may, however, be modified by circumstances. If either the dryness or the excessive moisture of the area impedes the growth of plants during their first youth, the very best place should be selected for a nursery.

Position and Soil of Nursery.

A northerly aspect on hill sides with side protection against east and south is always a favorable position. Sowing nurseries will suffer but rarely from frost, and the north position has the advantage that the vegetation begins later, and the plants can be transplanted further on in the season. A slope is desirable, but it must not be too steep, or the rain will wash away the good soil, and perhaps cover the young seedlings with earth. A soil intermixed with sand is more easily kept clear of weeds than a clayey soil. Loam soil containing no lime forms a hard crust after each fall of rain, as mentioned in a former chapter, and must be avoided. Wet soil is quite as bad, and old grass banks should never be selected. The place should, of course, be chosen as close to the projected planting operations as possible. In the plains, a place easily to be watered should be selected. Spots on which trees have been newly cut can be recommended, and for shade-loving trees it is well to make the nurseries in old thinly-wooded forests. The original shady trees may be carefully cut in the second year, in order to accustom the plants to the light.

Size of Nurseries.

The size of sowing nurseries depends, *first,* on the area to be planted, and, *secondly,* on the method of planting

When the seedlings are to be transplanted with the earth round them, it is necessary to make small and numerous nurseries to save cost of transport. But here again the cost of well-watering must be taken into consideration, and if a well has to be constructed or worked solely for a nursery, it is advisable to make the nursery a large one

Preparation of Soil

The place thus selected and the size decided on, the next thing is the preparation of the soil. The chief point to be considered in the preparation of a sowing nursery is, how to give the seed a mild, loose soil for germinating, unencumbered by weeds. As it is in most cases desirable to concentrate the roots into the upper portion of the soil, great care must be taken to loosen it well and to collect the best earth near the surface. If, however, the seedlings are to be ultimately transplanted into very dry soil, or on a very dry position, the roots should be lengthened, which is easily done by loosening and improving the lower soil The depth of digging a sowing nursery may therefore vary between 5 inches and 1½ foot, according to circumstances; but whatever the depth may be, the soil must be thoroughly cleared of all weeds and their roots This must be done most carefully, so as not to remove the best soil and the dissolved nutritious substances The best way is to prepare it roughly a season beforehand, and to allow the weeds to remain lying on the surface Heavy soils should be loosened and improved with humus or ashes. The last work, before the sowing actually commences, should consist in frequently hoeing up the soil, forming beds and laying out roads The beds, especially in the hills, must be as level and even as possible to prevent either soil or seed being washed away It is desirable to allow the soil to settle down before sowing, and if time does not admit of this, it will be found advantageous to beat or press it down with boards

SOWING.

Condition of Soil

The condition of the soil at the time of sowing must be taken into consideration, especially if it be heavy If the

soil is immoderately wet, the seed will germinate badly, particularly if the ground is of a clayey description.

Time of Sowing.

In the watered plantations of the plains, the time of sowing nurseries is mostly during the early spring. In the hills, the seedlings will prosper as well, and often better, for having been sown late in autumn, and *Pinus longifolia* succeeds best when sown during the rains.

Manner of Sowing.

The sowing may be done either broadcast, or in lines. Seedlings to be transplanted in the first year may be sown broadcast, on land watered with wells, provided the soil is free from weeds This method of sowing facilitates the removal of plants with the earth round them In all other cases sowing in lines is preferable, because :—

1 Less seed is required.
2. The seedlings are more easily kept free from grass and weeds.
3 There is less difficulty of removing the plants and less risk of damaging the roots

Broadcast sowings must be made with a sparing hand, as the plants have to be taken up with the surrounding soil, but strip sowings may be sown more thickly. It must be borne in mind that a thick sowing has the advantage of ensuring the germinating on heavy soil where single germs cannot penetrate, and that it is more easily kept free from weeds, as the young plants protect each other against weeds and frost. But if it is necessary to leave the plants for a long time in the sowing nursery without transplanting, or if they belong to a rapidly-growing class, their development is decidedly impeded by a thick growth, and therefore a thinner sowing will be necessary.

In another chapter, where each tree is treated separately, I will notice the quantity of seed to be sown

The covering can, or must be, thicker than in open sowings; the earth being loose and clean allows air and moisture to come into contact with the seed.

Broadcast sowings are best covered with a rake or by strewing earth thinly over them.

Strips may either be made with a small hoe or, when small seed is to be used on light sandy or humus soil, with the "strip board" (*see Fig 7*)

The "strip board" is about 4 feet long and 3 feet broad, with parallel staves nailed lengthways at a distance of 8 inches These staves are about 1½ to 2 inches high by ¾ inch broad, and slightly hollowed out in the middle The board is put on the ground with the staves downwards. A man steps on the board, and the strips are pressed into the ground. By means of the hollow in the centre of the staves an elevation is formed in the middle of the strips, and the seed will fall on both sides of it, which affords a decided advantage. The seed sown in strips is again covered by spreading the soil with a rake over it and pressing it down A cover, however, of loose artificial soil (a mixture of humus, ashes and soil) is most advantageous, as it is easily penetrated by the germinating plant A popular mistake exists that it has a pernicious effect on the germinating plant to assist it breaking through the upper soil On the contrary, this must be done if a crust has formed on the surface The earth must be lifted with the hand and crushed If the soil is liable to form a crust, the best way would be to cover the sown strips with moss, and only remove it when the plants have appeared above ground In the plains, as well as in the hills, a covering of shrubs is advisable before the rains begin, especially in unwatered nurseries The seed before germinating has to be carefully guarded against birds, insects and mice, and against the last-named enemy even after the young plants have made their appearance

Future Treatment of Seed Beds.

During the first two years, the seed beds have to be kept free of weeds, and the soil between the strips must be loose, so as to afford easy ingress to moisture and air In the second year the same can be effected by covering the soil between the lines with a thick layer of moss. This simple process will protect the plants in the higher hills.

and at the same time prevent their freezing down. Against this latter danger a covering of pine branches or *Indigofera* in autumn will prove effectual. In spring this covering is to be removed *gradually*.

Removal of Seedlings

When the seedling is fit for transplanting, the next question is its removal. The taking-up with earth is best done with the circular spade, or hollow spade, or *khúrpa*, and has been discussed before More difficult is the taking-up of plants without earth, and the greatest care must be taken to keep all the fine tender roots (indispensable to growth) undamaged. The best way is to approach the strips from the side by means of a small trench at a short distance parallel to the strip. The plants are then pulled into the trench, helped with a spade from behind, the earth between the roots is removed by a gentle shaking, or, if very binding, it is picked off with the hand

Damaged or weak seedlings may be transplanted into a planting nursery to recover or be thrown away, but they should never be used for immediate cultivation. The holes made by the removal of plants should at once be filled up with good soil. The fine roots, which are of the greatest importance, dry up very quickly, and the plant becomes unserviceable. The best protection is, of course, an immediate transplanting, but if this is not feasible, they must be protected by a covering of earth, wet moss, or wet leaves, and by dipping them into water before planting. This is absolutely necessary if they have to be transported a considerable distance.

Protection of Young Plants.

If the seedlings cannot be planted immediately after reaching the place of cultivation, it is necessary to cover at once the roots completely with *fine loose* soil Great care must be taken to do this efficiently, so that no air can penetrate between the roots. For the same reason it is necessary to untie the plants, should they have previously been tied up into bundles

Change of Nurseries.

A change of sowing nurseries affords many advantages, as it ensures fresh, active soil, shortens the transport, &c, but the disadvantages must not be overlooked; the cost of the first preparation of the soil, cost of fencing and greater danger from weeds, must all be taken into consideration. In most cases therefore, especially in our hill forests, a sowing nursery has to be used more than once, but should then be artificially manured with humus and ashes It is not advisable to utilize manure prepared from decomposed weeds and grasses taken out of the nurseries, as many a germinating seed of the weeds will again find its way into it All things considered, it is cheaper to bring the humus from a well-shaded part of the forest where no weeds grow.

PLANTING NURSERIES.

Soil and Position of Nursery

The soil for the planting nursery must resemble as much as possible the soil on which the trees are to be transplanted, but there is no necessity for its being as mild as that selected for sowing nurseries, as the plants to be reared here have already complete roots and a complete system of digestive organs The plants taken out of a planting nursery are larger, the preparation of soil is more expensive, as well as the fencing, &c, and therefore these species of nurseries are but rarely changed. This entails keeping the means of transport in view when selecting a place for a planting nursery, and to choose, if possible, a place easily accessible to wagons

In the plains an easy supply of water is indispensable, and even in the hills it outweighs many other disadvantages The nursery must be easy of access and close to supervision.

The soil should possess the necessary productive power, and must not be poor. On poor, inactive soil the plants degenerate, and become perfectly unfit for an unprotected position The best vegetation is ensured on places where the forest has been newly cut, and where the ground has a good humus cover Such places are far preferable to those exposed for a considerable time to every atmospheric

done if the plants are intended for replenishing an insufficiently stocked forest, where they will again receive protection

Planting of Nurseries.

The nurseries once prepared, the planting material must then either be brought out of the forest, which is the most uncertain method with untrained coolies, or must be raised from seed—a subject which has already been discussed

The planting itself is executed in parallel lines, at a distance of 8 inches to 2½ feet, according to the size of the plants to be grown, but depending at the same time to a certain degree on the species of trees. The same reasons determine the distance of the trees in the lines, which may vary from 3 inches to 2 feet, or even 2½ feet

For first planting the most customary method is to make with a hoe small trenches, 3 to 5 inches deep, along a rope; the plant is then put in its place, and the soil is drawn on with the hand and well pressed down The use of a better kind of soil for covering, or of a soil mixed with ashes, is advantageous, as it will not only draw the roots to the surface, but will also accelerate the growth

Very small plants may be put in, like cabbages, with a planting stick, in which case, however, no superior kind of earth can be put round the roots, and great care must be taken to press the soil well on the roots

Second Transplanting.

A second transplanting, after the trees have attained the height of 3 to 5 feet, makes the cultivation unnecessarily expensive, and can only be warranted when it is contemplated to raise stately avenue or garden trees

Pruning of Roots and Branches

All torn parts of the roots of plants should be cut off with a sharp knife The clear cut will admit water freely until such time as a new set of fine roots have formed above the wound It is therefore unnecessary to prune the roots of plants which have been taken out so carefully as not to cause damage to any portion of the roots.

influence. The condition of the soil is the primary consideration; it must be fresh, active, and, if possible, rich. The position should be as elevated as is consistent with a thriving growth of the trees to be planted. Plants are safer there against night frosts than in dells, and the transport is easier downhill than uphill. The position should be as level as possible, as plants brought up on a level place endure best thé various changes of position A plant reared on a level is able to resist more sturdily the effects of a steep north side than one grown on a south slope.

Size of Nurseries.

The size of nurseries depends of course on the requirements of the case and the means at disposal

Preparation of Nurseries.

Nurseries which have to serve for a period of years must be carefully dug to the depth of 1 to 1½ foot, and cleared of all roots, stones, &c. Roads must be laid out and a durable fence put round it. In fact, it must be altogether prepared like garden soil If poor, it must be intermixed with ashes and humus; but it should never be dug deeper than 1½ foot, as in most cases we purpose having the nourishing root as close to the surface as possible

The roads depend entirely on the size of the nursery, which should be divided into beds of a twelfth of an acre, or even smaller. In large nurseries situated in the plains, or wherever the planting material can be removed on wagons, the roads should be broad enough to allow the wagons to come up to the beds.

The fences should be durable, and may be made either of stones, wood, or wire. For large nurseries it is advisable to have a small hut with lock and door on the spot. It prevents coolies and their sub-overseer leaving the work on a rainy morning, followed, perhaps, by a fine day, and may serve as a place for tools, &c.

Planting under Protection

Shade-loving plants, like the deodar, may be planted under the protection of old trees, but this should only be

done if the plants are intended for replenishing an insufficiently stocked forest, where they will again receive protection

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Neither the roots nor the branches of pines ought to be pruned, as the resin in the tree closes up quickly every wound.

Pruning of the branches is necessary to restore the equilibrium between the roots and branches, and in some cases to guide the growth.

A careful pruning of the roots of certain plants often tends to concentrate them into a small space, and thus facilitate the transplanting process. The pruning must be executed with a very sharp instrument, either pruning knife or scissors If the roots are to be pruned for a second transplanting in the planting nursery, it is necessary to cut them so short that the newly sprouting roots, which always grow in a circle just above the cut, can be easily admitted into the planting holes

Cutting-Down of Plants.

If the plants have suffered by drought, frost, mice, or cattle, the whole stem may be cut off, and a fresh coppice from the root form the new stem This course may be pursued if the plant sickens on poor soil, or under cover of larger plants or trees If the top of a plant is to be cut off, great care should be taken to leave a healthy bud just below the cut. Branches must be cut so as to produce the smallest wound; roots have to be cut horizontally, parallel with the bottom of the plant hole.

Protection of the Roots and Watering.

During the inspection and pruning of roots and branches, the former
is near, it
planting is

During the dry season it may be necessary to water the transplants, even in nurseries which depend entirely on natural rainfall. The evening is the best time for watering, and, when once begun with, must be continued till the rains set in.

Clearing of Nurseries.

Planting nurseries have to be treated in the same manner as sowing nurseries, the chief care being to keep them

clear of weeds and loosen the soil constantly. This latter point must not be neglected, as it encourages the formation of roots near the surface During the first year, the surface soil should be loosened four and five times, but in the second and third year two or three hoeings will suffice It depends entirely on the kind of soil and species of trees to what depth the soil must be loosened. Pine will not stand the same depth as deciduous trees, and clay or other binding soils require a deeper digging than sand or other loose soils A covering of moss or leaves immediately after loosening the soil has the same effect as repeated hoeings

Training of Plants.

Plants are capable of being trained in nurseries by means of pruning If a stem is bent, it will grow straight by cutting away the branch growing on the bent or elbow (*see Fig* 8) If plants grow too bushy, it is often necessary to cut off some of the branches, and again, if the top is weak, broken, or diseased, it must be cut and one of the side branches trained into a new top

Planting-Out

The time for planting out seedlings depends not so much on their age, as on the progress they have made. The removal of plants has been discussed before. Deciduous trees, even if they be of a considerable size, will prosper if taken out of the training nursery with only 8 or 12 inches of their tap root, and their chief side roots

As mentioned above, planting nurseries are not often changed, and it becomes therefore necessary to vary the species of trees to be raised and to dig up and manure the place Decomposed leaves or ashes of leaves, of the species of trees to be grown, make the best manure. In case a planting nursery is given up, plants enough should be left in it to grow into a thicket.

Reproduction by Means of Cuttings

The system of reproduction by means of cutting is based on the fact that the buds formed in autumn hold within

themselves all the material for a new specimen of the same species. Some species of trees have the power to develope these buds into roots below ground, and, under the influence of light, into leaves above the surface. This power is most strongly developed in the willow, tamarisk and poplar species The sissú and others possess it to a considerable degree, and are therefore capable of reproduction by planting, or setting of twigs without roots. To obtain this end before the trees begin to sprout, we cut twigs of perfectly-formed wood in such a manner as to have a bud or buds near both ends, and place them, standing, into loose, moist soil from 6 inches to 1 foot deep. Twigs a year old are best adapted for this purpose

On very wet soil it may be necessary to plant larger cuttings, from 2 to 3 years old wood should be selected, and cuttings from 6 to 8 feet high used They should be planted from 1 to 2 feet deep, and holes should be made into the soil with an iron or wooden pole When the soil is very hard, the holes have to be dug, and the young seedlings must be surrounded with a superior kind of soil. It will be found beneficial to keep good, rich earth around the seedlings *above* ground when the soil is very wet, or when it alternates between excessive moisture and dryness, and also on perfectly dry soil. By this means the buds above the original surface will be able to strike root in a dryer place if the soil be unduly wet. On very dry spots this heap of superior soil prevents evaporation, and on alternating soil it causes the changes to be less rapid, and prevents the cracking of the surface. Should it be found necessary to collect cuttings before the planting operations can be undertaken, they should be taken to the place of cultivation, dug half into the ground, and shaded Before planting it is well to half-immerse the cuttings in water for a few days; this is especially advisable if they have been brought from a long distance.

The *sine quâ non* of success is, that the buds in and above ground be perfectly undamaged, and that the earth closes firmly around the cutting.

It is always advisable to make the hole with a stick, or if lines of willows have to be planted for protection against the river, the best way is to dig a ditch with a slanting

side, place the cuttings on it, and re-fill the ditch. Under no condition should the cuttings be stuck into the soil without a hole being previously made with some kind of instrument It is a mistake to leave a disproportionate number of buds above the soil, and if tall cuttings are planted, it is well to pick off some of the lower buds The best time to set cuttings is the early spring, or the rains.

Reproduction by Means of Layers.

This method is based on the same physiological fact. A branch of a standing tree is bent downwards and buried into the ground with the ends protruding above the surface The branch is left thus till roots are developed under ground, and is then separated from the mother tree. This method, called in French "*marcottage*," though hardly of any value to the Forester, is of great use in gardenings, or for the propagation of foreign trees which either do not bear, or are too young to bear seed, or, if it be found difficult to procure seed, the branch may be conducted through a flower-pot or box filled with earth, which facilitates the future transplanting The early spring is the best time for the burying of layers (*see Fig. 9*)

Reproduction by Means of Grafting and Budding.

The object of this method is to reproduce the good qualities of one variety on plants of the same species—qualities impossible to reproduce by means of seed. Grafting is usually resorted to when the plants cannot be raised from cuttings. It depends also on the capability of the bud to produce a new specimen. Success is only then ensured if heed be taken that the different parts of the graft or bud come into close contact with the identical parts of the tree on which they are to be grafted.

Particular care must be taken that the *cambium* contained in the graft touches the *cambium* of the tree, and that external air be excluded from the wound. If this is observed, the wood-forming sap, descending from the budding graft or bud, will form cells sufficient in number and size to close the wound and to establish the normal circulation of the ascending and descending sap.

The following are the instruments and materials wanted for the grafting process:—

1. A small sharp hand-saw to cut the trees or branches intended to be grafted.
2. The grafting knife for cutting and setting the graft or bud (*see Fig 10*)
3. The ligature to keep the graft or bud in its place. The best and most elastic ligature is coarsely-spun wool. For thicker branches or stems, however, the bark of trees soaked in water before being applied may be used.
4. A compound composed of several ingredients to keep the air from the wound The simplest is cowdung and loam, which cannot, however, always be recommended, as during hot, dry weather it is liable to crack and to let in air. During the rains, parts of it are easily washed off, and many small insects are attracted by it, and breed between it and the bark Resinous mixtures have none of these drawbacks, but they must be made so as to be able to resist the powerful influence of the sun

I annex a good recipe:—

Pitch	28	parts.
Resin	28	"
Beeswax	16	"
Tallow	14	"
Sifted ashes	14	"

This mixture is made just liquid over the fire and applied with a brush.

BUDDING.

The setting of a sleeping bud may be either done with one bud or with a flute-like piece of bark with two or more buds on it A short explanation will suffice, as both methods are best explained by *Figs. 11* and *12* As a rule, trees are budded when young, and only then when they are in sap, either in spring or autumn.

Healthy buds in the axis of a leaf are selected and carefully detached from the branch in form of a shield, in such a manner as to preserve intact the knot of a cellular tissue which is found below the bud. If this cellular tissue is not perfectly preserved, it is useless to set the bud, as the power of development is lost It should be mentioned that the grafting bud must at once be placed into wet moss The bark of the tree to be budded is then cut in form of a T down to the splint, and both sides are loosened with the lower end of the grafting knife The bud is placed into the incision, and the ligature and resinous mixture are applied. They are taken off as soon as a swelling and the growth of the bud indicate that a sufficient connection has been established between the bud and the stem.

If the budding takes place in spring, the stem is cut just above the bud, immediately after the operation is finished; but should the budding be undertaken in autumn, the cutting must be deferred until the following spring. When the operation is to be executed in autumn, the leaves in the axis of which the bud has formed must be pinched off a fortnight before the inoculation takes place, as this will facilitate the separation of the bud from the mother tree. When the new shoot begins to form, care must be taken to protect it against the influence of winds, which are apt to tear it off If, however, a flute-like piece of bark, with several buds attached to it, is used for the budding process, this danger is to a certain degree obviated, but the method requires much practice and care. The branches from which the buds are taken must be of the same thickness as the tree or branch about to be grafted. A piece of bark bearing several buds is loosened from the graft, and a piece of the same dimension, without buds, is detached from the tree to be budded. The piece of bark from the graft is accurately fitted into the wound, the ligature is applied, and the air is kept out by covering it with the resinous fluid. Trees or branches are cut above the buds in spring only, exactly as described before when treating of the single bud

Another way may be mentioned here. A branch of equal dimensions as the tree to be budded is buried for

fortnight in a shady place. The tree is cut down, and an inch of bark is detached all round. An inch of bark in form of a flute and bearing buds is then taken from the graft, drawn over the stem of the tree in place of its own bark, and the wounds closed with the resinous mixture (*see Fig. 13*). This operation can only be executed during spring, as it entails the cutting of the tree or branch before inoculation.

GRAFTING.

We may graft either into an incision made into the wood, or without wounding the wood portion of a tree.

The first method may be used either in autumn or spring, and this constitutes its chief advantage. The graft should be about 4 inches long, and have a bud on the upper end. The lower portion of the graft is then cut slantwise, and a similar incision is made into the tree, taking great care not to injure the bark. The twig thus prepared is placed into the incision, so that its *cambium* comes into close contact with the *cambium* of the tree The ligature and resinous fluid are applied and taken off when the graft begins to grow. There are varieties to this method: graft and incision may be made triangular, or in form of a zigzag, as shown in *Fig. 14*, but the execution remains the same.

Grafting without making an incision in the wood can only be executed when the vegetation is far enough advanced to admit of an easy separation of the bark from the wood. The branches or tree to be grafted are cut, the bark is laid open vertically down to the *cambium*, and the sides of the incision are loosened (*see Fig. 15*). The graft must be cut slantwise, so that it terminates in bark only; it is then placed into the incision in such a way that the wounded side touches the *cambium* of the tree The ligature and air protection is then applied.

The graft may also be set on a side root of the tree from which it is taken (*see Fig. 16*). A new specimen of the same tree may thus be produced, though other varieties of the same species may not be obtainable.

The last method to be mentioned here is the joining together of two standing trees of the same species by

wounding both in a precisely similar manner and tying the wounds together

SYSTEMATIC PLAN OF CULTIVATION.

Before cultivation is undertaken, all preliminaries should be settled and a system for the cultivation drawn up Safety belts must at once be laid out wherever they are required, and draining or watering arrangements must be completed before the actual work is taken in hand. Sowing and planting nurseries ought then to be laid out on the most suitable spots, and every thing arranged with foresight and prudence.

Nothing endangers future success of cultivation so much as undue hurry, even if the increased cost be not taken into account. When very small plants are used, in order to save a year or two, or when, for the same reason untrained seedlings are taken out of the forest, the inevitable result will be to retard the entire cultivation Numerous repairs and replenishings will be required, as such seedlings are more susceptible to the inclemency of the weather than stronger plants Provision for the immediate replenishing of the cultivation ought to be made in the beginning of the operations, and this is accomplished by growing the plants dense enough on good selected places to yield planting material.

A combination of sowing and planting is often advisable, as well as a combination of either, or both, with natural reproduction. I cannot warn too strenuously against the rigid adherence to one method, and especially against a repetition on the same spot where that method has failed The error of this proceeding will be most apparent where sowings have been executed; for here the soil gets covered with weeds and grass and generally deteriorates, and with every new attempt the success of the cultivation becomes more uncertain.

Cost of Cultivation.

A point of great importance is the cost of cultivation. After the manner has been decided upon, a plan operation for the actual cultivation has to be made.

Executive Officer has to decide when he intends to begin work, and in what direction he will work. He must also make up his mind how many laborers he intends to employ for each branch of the operation? for it is with cultivation as with any other kind of work—its cheapness depends on the proper division of labor. If the removal, transport and planting of material is so combined that all the workmen are employed together, the cost of labor will be materially reduced, and the Executive in direct charge will receive much *kudos.*

The utmost thriftiness in the execution of cultivation should be observed, but not to such a degree as to retard or impede the work in any way In fact, the work must always be our first consideration, and the cheapest labor is that which turns out a success Annexed is a list of different descriptions of works and the cheapest way to execute them

1 The most economical way to have earth-work done is by contract; but if it is found necessary to have it executed by daily labor, strong and able-bodied laborers should be employed. When nurseries are to be prepared, it is always advisable to have it done by daily labor
2 Sowing of seed in lines or places is best done by grown-up boys or women. Not so broadcast sowings, which require strength and a certain manipulation (daily labor to be employed).
3 The actual digging-up of plants, as well as the pruning, should always be entrusted to expert and strong laborers (daily labor to be employed).
4 Wagons are, of course, the cheapest carriage for transplants, but when this is not feasible, strong laborers ought to be employed, or the transport may be given in contract
5. The carriage of single plants to their respective places is cheapest done by boys.
6 The planting, especially of plants without earth, is best done by women, as it does not require much strength, but only care and gentle manipulation. This is the most important portion of

the cultivation work, and should always be done by daily labor. Another point must not be omitted. Good implements will considerably lessen the cost of cultivation If they are not properly steeled and sharpened, much time, labor and money are lost, and in the end it will repay Government to buy proper tools and to pay for keeping them in good working order.

Before the beginning of the new official year, accurate proposals of all intended cultivations should be sent to the Conservator for approval, together with an estimate of cost. This should be done in an easily revised tabular form. To facilitate this proceeding, I give, in conclusion, a useful form and tables of costs of the most common methods of cultivation

To dig 1 acre of nursery 1½ foot deep, and to prepare it like garden land costs:—

For bár land . . .	Rs	113	0	0
For moist soil	„	66	14	0

On sailába land a plough may be used with advantage, and the preparation of 1 acre will cost only Rs. 12.

One coolie can sow from 500 to 600 square feet of nursery per day.

To dig 1,000 running feet of trenches 1 foot deep by 1 foot broad, and to throw the earth up as a ridge for sowing, costs from Re. 1-12-0 to Rs 2.

One laborer can prepare for sowing 800 running feet of this ridge *per diem*, and one man can sow 1,650 feet.

Statement showing the Number of Holes of Different Dimensions in Dry and Moist Soil that can be dug by One Coolie per Diem.

ON BAR LAND								ON SAILABA LAND							
MOIST SOIL				DRY SOIL				MOIST SOIL				DRY SOIL			
1 foot	1 foot 6 inches	2 feet	2 feet 6 inches	1 foot	1 foot 6 inches	2 feet	2 feet 6 inches.	1 foot.	1 foot 6 inches.	2 feet	2 feet 6 inches	1 foot	1 foot 6 inches.	2 feet	2 feet 6 inches
90	60	20	10	50	30	15	7	100	75	30	15	65	35	25	10

Statement showing the Number of Trees of Different Dimensions with and without Earth that can be dug out by One Coolie per Diem

ON BAR LAND								ON SAILABA LAND							
WITH EARTH				WITHOUT EARTH				WITH EARTH				WITHOUT EARTH			
75	40	28	24	700	500	250	200	100	65	40	25	500	300	100	50

Statement of Transport of Plants with and without Earth by Basket, Hand-barrow, and Wheel-barrow.

Description of carriage	Length of root		200 yards	400 yards	600 yards	800 yards	1,000 yards	1,500 yards	2,000 yards	3,000 yards	Remarks
	Ft	In									
Basket	1	0	194	96	63	48	45	30	24	15	With earth, one man
	1	6									
	2	0	168	88	57	42	36	30	18	12	
	2	6									
Hand-barrow	1	0	216	108	70	50	43	30	21	12	With earth, two men
	1	6									
	2	0	144	72	48	36	29	19	14	9	
	2	6									
Wheel barrow	1	0	128	70	48	36	20	20	16	12	With earth, one man
	1	6	90	60	45	33	21	15	12	8	
	2	0	64	40	24	20	16	12	8	6	
	2	6	32	18	13	9	7	5	3	2	
Basket	1	0	16,000	7,000	4,500	4,000	3,500	3,000	2,000	1,000	Without earth, one man
	1	6	12,000	6,500	4,000	3,200	2,200	1,600	1,200	800	
	2	0	7,800	3,900	2,600	1,950	1,620	1,300	1,040	780	
	2	6	4,500	2,250	1,500	1,200	900	600	450	300	
Hand barrow	1	0	25,000	12,500	8,250	6,250	5,100	3,000	2,000	1,500	Without earth, two men
	1	6	22,500	11,250	7,500	5,500	4,500	3,600	2,700	1,800	
	2	0	12,000	6,000	4,000	3,000	2,400	1,600	1,200	800	
	2	6	9,000	4,500	3,000	2,250	1,800	1,200	800	500	
Wheel barrow	1	0	Same as basket								Without earth, one man
	1	6									
	2	0									
	2	6									

Plants without earth are usually tied in bundles and carried on the head

Statement showing the Number of Plants of Different Sizes a Cart will hold, and the Number of Times it can go the Distance of One Mile

1 foot.	1½ foot.	2 feet	2½ feet.	REMARKS.
	Without earth.			
14,000	12,000	10,000	6,000	Four journeys.
	With earth			
600	400	225	169	" "

Statement showing the Number of Plants of Different Sizes that can be planted by One Man per Diem with Earth.

ON BAR LAND.				ON MOIST SAILABA.			
1 foot.	1½ foot.	2 feet.	2½ feet.	1 foot.	1½ foot.	2 feet	2½ feet.
49	37	28	19	80	50	34	20

With the peg on previously irrigated land one man can plant 130 transplants without earth *per diem*

One laborer can prepare 700 cuttings per day, and one man can plant in moist soil 400 of them in a day.

One bhistí can water between 500 and 600 transplants per day if the water is on the spot.

PATTERN SHEET.

Arboriculture Proposal

Running No.	Species of tree to be cultivated.	Description of cultivation	Labor, Seed, &c.	CONDITIONS OF SOIL								
				FAVORABLE			UNFAVORABLE.			VERY UNFAVORABLE.		
				Days.	Rupees.	Annas.	Days.	Rupees	Annas.	Days	Rupees.	Annas
1	Dalbergia Sissú ...	Nursery of ¼ acre on canal irrigated land	Labor for preparing soil	3 as. 90	16	14						
			Seed ⅛ maund			8						
			Sowing	21	3	15						
			Watering	..		12						
			Weeding	20	3	12						

CHAPTER II.

NATURAL REPRODUCTION.

Definition of the term Natural Reproduction.

Natural reproduction includes all reproduction by means of seed shed by mature trees in the forest, or by means of coppicing from the roots of cut trees, or by a combination of both.

Instances when Natural Reproduction is advisable.

Trees which require much protection during their youth, such as *Cedrus Deodara*, may be reproduced with advantage in a natural way. The same course may be adopted with other trees in exposed positions, and if the cuttings are executed by selection. It may also be recommended on steep, stony and rocky slopes; further, where labor is scarce, and on places where a good young growth is already standing.

Instances when Natural Reproduction is impossible.

Natural reproduction is impossible on extensive blanks, or where the species of trees forming the mature forest are to be changed, or where the trees are too old to bear seed or to coppice, or where the condition of the ground or nature of its covering does not admit of the germination of seed and the growing of small seedlings. The soil may be too wet or too dry, too hard or too densely covered with weeds.

Management of Naturally Reproduced Forests.

The management of naturally reproduced forests is divided into two great classes. The first is called the "High Forest Treatment," when the forest is reproduced by means of seed; the second is called the "Coppice Forest Treatment," when the reproduction depends on the coppi[illegible] the stock. A combination of both methods, that is [illegible]

when reproduction is achieved partly by seedlings, partly by coppice, is called "Coppice under Standard Trees."

High Forest Treatment.

The first condition to ensure reproduction by means of naturally-shed seed is to allow the trees to grow up to maturity until they will yield productive seed. A preparatory cutting to strengthen the trees, or to prepare the ground, should then be made; and when this has been accomplished, a second cutting must be made, in order to admit enough light and air into the forest to allow the seed on the ground to germinate. After the young seedlings have sprung up, one or more new cuttings may be made to encourage and strengthen the young growth by a further admission of light. As soon as the young growth seems strong and dense enough to expand into a new forest, the rest of the old forest must be cut down.

Preparatory Cutting.

The trees in a forest may be full-grown but still bear no seed on account of their close growth; and if such a forest is to be reproduced, a judicious thinning out, or preparatory cutting is advisable, as it will promote the formation of seed.

The formation of roots in a dense forest is not sufficiently vigorous to afford the necessary support should the forest be severely thinned, and the trees suddenly deprived of their mutual support. It is therefore always dangerous (and on exposed positions impossible) to begin at once with a cutting severe enough to allow the germination of seed. Not only would the standing forest be endangered, but natural reproduction would be rendered impossible after the regularity of the old forest had been destroyed. A preparatory cutting is required here to strengthen the power of resistance of each individual tree.

The soil in a dense forest is often covered with a thick layer of leaves and mosses which sometimes prevent the small roots of the seedlings to penetrate the soil. Here, again, a preparatory cutting must precede the cutting necessary to promote germination The free admission of

air, light and moisture will accelerate the decomposition of the obstructing layer.

Further Use of Preparatory Cutting.

Trees of a less valuable species are often found intermixed with those we wish to cultivate. In such cases, many of the inferior trees are removed by means of a preparatory cutting, and the more valuable ones are left in the forest as parent trees

If the seed crop of a year fails, the cutting for germination of seeds must be omitted; but as we have still to supply the markets and depôts with timber, the preparatory cuttings of the block which stands next for reproduction must yield the necessary material.

Rules for Preparatory Cutting.

The severity of the preparatory cutting depends on various conditions. For instance, if by means of the preparatory cutting we wish to promote the formation of seed in backward trees, we must cut severely, less so if the trees have already begun to bear fruit. We must also have recourse to a more severe cutting if we purpose to decompose a cover of leaves and mosses. If we only want to loosen a soil which has deteriorated and hardened through the removal of leaves and humus (*streunutzung*), a more lenient cutting will suffice. Under any circumstances the clearing should never be so severe as to cause the formation of a grass cover.

The preparatory cutting should never extend over a greater area than may easily be put under natural reproduction, otherwise it will lead to the deterioration of the soil.

In weak and very irregular forests a repeated lenient preparatory cutting may be advisable.

An indispensable condition to the success of natural reproduction by seed is the careful protection of the leaves, moss and humus cover in the forest, for some years at least, before the natural reproduction begins and during the whole period of reproduction.

General Rules for Cutting to promote the Germination of Seed.

I—Direction of Cutting.

(a) All cutting in a forest must begin on the sides protected against the prevailing storms. We must, so to say, cut *against* the wind, and the most exposed portion must be taken in hand last of all. This precaution is especially to be observed in coniferous forests, as the pines, with their tall trunks, perennial leaves and shallow formation of roots are more exposed to the ravages of storms than deciduous trees. The precaution is, however, equally necessary as regards canal-irrigated or inundated forests.

(b) A protective belt should be left (or even created before the cutting begins) on spots exposed to the hot, parching winds in the plains, or to the frosty breezes and avalanches in the hills.

(c) The cutting must be executed in such a way as to facilitate the entire covering of the soil with seed, which can only be achieved by an equal distribution of the seed trees.

(d) The line of cutting must proceed in such a direction as not to endanger the seedlings which have already sprung up during the removal of timber. In hill forests, we must therefore not begin our cutting close to the riverside, as all the timber of future cuttings would necessarily have to be transported through the young growth of previous years.

II.—Amount of Cutting.

In a regular mature forest, the crowns of trees form a dome under which little or no vegetation is to be found. When natural reproduction is contemplated here, we must cut, over the entire area to be reproduced, enough trees to admit everywhere light and dew sufficient for the germination of the seed and the first growing of the young plant. Different species of trees and different soils and situations should also determine the amount of cutting.

(a) The young seedlings of the generality of trees require more or less protection against sun, wind, cold and drought; the amount of cutting must therefore vary according to their different requirements. Some plants, like the

Deodar and Tún, will often wither away if suddenly exposed to the influence of the sun and drought; others, like *Pinus longifolia*, may spring up in a shady forest, but disappear again during the first year of their lives.

(b) The cutting must be somewhat lenient on soils which have a tendency to be overgrown with grass or weeds, or which are inclined to dry up rapidly.

(c) In a rough climate, where frost is apt to endanger the young growth, the cutting must not be as severe as in milder regions. Thus it is necessary to cut leniently on north and east slopes, and more severely on south slopes. There is another reason why a larger amount of trees should be cut on a south slope: a dense growth overhead prevents the dew and rainfall, which is especially wanted on the warmer south side.

III.—Manner of Cutting.

Sound trees, with regular but small crowns, should be left as seed trees They must be distributed as equally as possible over the entire area, and should be selected with the greatest care and by a responsible officer, as the whole success of the natural reproduction may depend on this selection. Trees whose very dense crowns overshadow the ground ought to be cut, as well as very large trees, which would destroy during the process of felling a larger amount of young growth than trees of a smaller size would. In deciduous forests the selection should be made when the trees are in leaf. The time of cutting must be regulated in such a manner that the whole forest is cleared of timber before the seed-fall. The soil recently disturbed by the cutting, logging and transport of timber will form an admirable receptacle for the falling seed. The removal of the stock of felled trees increases the susceptibility of the soil, and is always to be recommended, except in positions much exposed to storms, as the roots of standing trees are often inadvertently cut off with those of the old stock, and the trees lose by this means some of their power of resistance. Artificial help, such as scratching-in of seed, loosening the soil, driving-in of sheep, rooting-up of weeds here and there, are always advisable and often necessary.

Cutting to strengthen the Plants.

In the course of their growth and development, the young plants require an increased amount of light and dew. In opposition to this want, the crowns of trees in opened-out forests exhibit a tendency to close overhead; and if the axe is not made use of to succour the young growth, the seedlings would soon lose their dark green color, turn yellow, the buds would grow thin and small, and probably the plant would perish altogether.

The second cutting should never be delayed until the appearance of these symptoms. If on account of one or more of the above-named reasons the first cutting has to be executed in a lenient manner, it must be followed up by repeated and careful cuttings with a view to strengthen the young growth and accustom it to an unprotected situation. This method of reproduction may extend over twenty and more years. One cutting to strengthen the plants is often sufficient, and the entire reproduction will be accomplished in about ten years. Other trees can, under favorable conditions, be thinned out at once so severely, that a further cutting before the clear cutting is unnecessary, or the forest may at once be cut clear in small narrow strips adjacent to the mature forest. Natural reproduction of great, broad clear cuttings cannot be expected.

Clear Cutting.

After a certain time the young growth is able to resist without further protection the influence of sun, drought and forest, especially after the plants have grown above the line of dew. Thickets now begin to close, and the blanks which may still be found on the area will be so over-grown with weeds and grasses that no further natural reproduction can be expected. This is the time when the last remnant of the parent forest must fall, to allow the new forest perfectly free scope for its development.

Necessary Precautions to be observed during Cuttings for strengthening the Plants, and during Clear Cuttings.

The young growth which has sprung up after the first cuttings ought to be protected against destruction during

subsequent cuttings. For this purpose the branches of the trees about to be felled must be previously cut, and the time for felling carefully selected. The best time is when the entire ground and the plants themselves are covered with snow, and the temperature is mild. Very cold days, especially if little snow lies on the ground, are to be avoided, as the plants are brittle and suffer with each touch. The early spring, too, when the plants are beginning to shoot, must be avoided.

All material must be brought as quickly and as carefully as possible on the nearest road, ride or slide; delay only increases the unavoidable destruction.

Treatment of the Area after Clear Cutting.

All blanks have to be filled up with transplants to secure a complete forest, and not a spot should be omitted on which a plant can grow. The more valuable species of trees have at once to be protected and fostered, and seedlings of minor value must be pulled out, especially if they impede or endanger the growth of the superior species.

Conclusion.

During the whole period of reproduction, from the time the first seedling sprouts, till a complete thicket has formed, the forest must be closed against cattle-grazing, cutting of grass, and collection of all other minor produce. In fact, an absolute exclusion of every disturbing influence must be strictly maintained.

Treatment of Incomplete and Irregular Forests.

We have discussed in former paragraphs the treatment of regular high forests under reproduction. In irregular forests, we find on the same area trees of all ages and sizes interspersed with blanks. Most of our Punjab hill forests present this aspect. To re-stock such a forest, we have to manage it with a view to future reproduction, long before the time for such reproduction has actually arrived.

The preparatory treatment consists—

1. In fostering the superior species of trees, especially those of the age required for reproduction

2 Patches of younger trees of the fostered species should be forced to maturity by means of severe thinnings.

3 A closing overhead should be attempted, and when this cannot be done with the means at our command, the ground must be preserved from deterioration by artificial cultivation, even of inferior trees.

4 An irregular forest should be closed against cattle at the time when the first preparatory step is taken, and the prohibition must not cease until the whole reproduction is a *fait accompli.*

5. Humus and leaves should never be removed till the whole forest forms a thicket of a more uniform age.

6. Preparatory cuttings have to be executed with special care and the recultivation of all considerable blanks must be taken in hand at the same time; weeds have to be removed on places where there is sufficient light to admit of natural reproduction, and the soil must be prepared with hoe and rake for the ready reception of the seed.

In fact, nature has to be assisted in every possible way.

Cutting for Germination of Seed.

On plots of mature trees, or where mature trees prevail, a separate cutting for the germination of seed should be executed. This cutting however must not be as severe as in a regular forest, for these groups standing separately, admit side light in proportion to their dimensions; each group in an irregular forest requires the same precaution against storms, dry or cold winds and sun as already mentioned for the protection of regular forests.

As a rule, the stronger trees in a group should be cut down in preference to the smaller-crowned trees, as the removal of a few of them admits a greater amount of light and air than the removal of double the number of small ones would. The smaller trees left standing will increase more rapidly in bulk than the large timber if left on the ground.

More vigorous efforts must now be made to ensure a total covering of the ground; hoe and rake must be in constant requisition, and wherever the natural reproduction does not come up, sowing and planting have to replace it Our sole aim must be to cover the soil and to prevent further deterioration No young trees, even if undersized or stunted, should be removed if we are not certain to be able to replace them immediately by young growth.

Cuttings to strengthen the Growth.

The same rules which apply to a regular forest under that heading are applicable here to every isolated plot of trees. We must now have recourse to planting and sowing of quick-growing, albeit less valuable trees

Clear Cutting.

As soon as a thicket has formed, though it may not be of an equal height or age, the parent trees have to be cut, and every blank must be filled up

It is decidedly wrong to sacrifice a *certain* reproduction for the sole purpose of attaining a greater equality of age in the newly-created forest, as it is perfectly easy to procure the desired regularity in the second rotation.

MIXED FORESTS UNDER HIGH FOREST TREATMENT.

Nature undisturbed by human interference created almost invariably mixed forests. Exceptions are only found in the far North, or on considerable elevations where the great variety of vegetation ceases, or where the peculiarities of the soil allow the thinning of particular species only.

We must not fail to profit by nature's own teaching; and though forests of one species have many advocates, the advantages of mixed forests are undeniable.

(1.) Mixed forests are safer from destruction by insects

(2) The formation of the roots of different trees varies, and a mixed forest has therefore a greater power of resistance against storms

(3) The reproduction of mixed forests is, as a rule, much easier; for when one species of tree fails, the other is sure to spring up, and such trees as require protection di

the earlier stage of their lives find it in the young growth of other species growing up with them

(4) As the soil is apt to deteriorate under trees with thin foliage, an intermixture is always attended with happy results. The soil is not only protected and better adapted for re-cultivation, but the growth of the individual tree is much more considerable.

(5) In many cases fires are prevented by intermixture, or, if they break out, they are much more easily extinguished

(6) The out-turn of material is very often greater, as well as more varied.

Mixed trees, in order to grow up together with advantage in one forest, must—

1. Flourish in the same climate and on the same soil.
2. Grow to maturity at the same period.
3. Require a similar treatment.
4. And, if possible, grow roots of different formation.

Rules of Treatment.

The general rules for the treatment of mixed forests are the same as those for regular pure forests, except that the trees of the more valuable species be fostered in preference to others.

Standard Trees.

A certain number of old trees per acre may be left standing on the ground when the rest of the parent forest is cut. These trees are allowed to grow up with the next rotation, and are called standard trees. The climate and soil must suit the trees intended for preservation; the position must be protected against storms, and the trees must be sound, and ought not to have large crowns. Trees with thin foliage, such as *Pinus longifolia*, are particularly adapted for standard trees, and species that do not suffer much from shade over head, such as Deodar, are best grown under standard trees.

CUTTING BY SELECTION.

Description of Cutting by Selection

Cutting by selection is the oldest and most natural way of utilizing a forest. The method, if it may be called so,

consists in cutting those trees which are required for the nonce. As long as the forest has only to supply the wants of a small forest population, the disadvantages of such treatment are little felt, or do not exist; but when markets have to be supplied and depôts to be stocked, the consequences begin soon to exhibit themselves. The strongest timber, generally of the most valuable kind, is cut down; the reproduction is left to accident; and the care of the Forester consists solely in getting the wood as cheaply as possible to the market, and selling it at the greatest profit. Such was, within the last few years, the treatment most of our Punjab forests were subjected to, and, I believe, are still subjected to in some places; and we observe incomplete, irregular, devastated forests with only partial reproduction. Such forests belong, according to our definition, to the high forest class. They are reproduced by means of naturally-shed seed; but the trees of different ages are mixed up on the same areas, and blanks overgrown with weeds abound

The Disadvantages of Cutting by Selection

The reproduction being left to nature, a failure in the seed crops causes often blanks. Places where trees have been cut get over-grown with grasses and weeds, and the seed of subsequent years, though abundantly shed, falls amongst weeds and thorns, and does not germinate. The young plants may be in the middle of a great blank, and have no protection whatever, or they may be smothered by the old trees The cutting and transport of old trees destroys unavoidably great numbers of young seedlings, besides damaging small trees The roads and slides must be more numerous than in a regular forest, whereby much space is lost. Cattle, which endanger a regular forest only during the time of reproduction, perpetrate the utmost mischief in a forest cut by selection, and must be kept out altogether, or they will destroy much of the young growth. Supervision of utilization, as well as of artificial cultivation, is in such forests much more difficult, and it is impossible to ascertain accurately the yield of a forest under this treatment

In some cases an uninterrupted protection of the soil is required to prevent landslips, or a forest cannot be cut, as it protects fields and forests below against avalanches, or serves as a belt against frequent storms. Under such conditions alone must we adhere to the method of cutting by selection Forests requiring such a treatment are generally of small extent, the reproduction is here the first question, and little or no heed is taken of the out-turn.

We begin by felling trees in the middle of the forest, and do not proceed with the utilization before the reproduction is secured by natural or artificial means. The branches of adjacent trees are often cut long before the trees are felled, to give light and air to young growth, and all possible precautions are taken to prevent damage while the trees are being felled.

Necessity of Regularity in, and Changing of, Cutting by Selection

When (as is the case in this country) great forests are still subjected to the treatment of cutting by selection, it must be executed with a view to establish a uniform and simultaneous reproduction. The first step in this direction is to divide the area of the forest into working compartments in accordance with the average age of the prevailing class of trees. The compartments which contain the oldest and strongest trees are utilized first, and the others are only cleared of decaying timber and diseased trees. The annual utilization should be restricted to the smallest area possible, and should be concentrated to one portion of the forest.

All rules enumerated under "Regular and Irregular High Forest Treatment" should be most carefully observed Groups of mature trees on good soil ought to be thinned when a seed year is indicated, so as to allow the germination of seed; young growth is to be fostered, and old trees must be removed where they oppress it, and thickets thinned. Preparatory cuttings, cuttings for the germination of seeds, cuttings to strengthen the young growth, clear cuttings and thinnings, are therefore executed on the same area with a view to equalize the character of the forest The other rules as regards protection against storms, care

in felling and removal of material, are the same as mentioned above under "High Forest Treatment."

No grazing must be allowed till the forest has gone through the entire process of reproduction, and all blanks should be filled up with artificial cultivation In spite of all these efforts, even if every compartment be treated in the above-described manner, we cannot expect at once a regular forest, though an improvement in the entire aspect must soon be apparent. The result will be a close forest, composed, no doubt, of trees of various ages, but which, nevertheless, may be reproduced in the form of a regular and complete high forest. All our hill forests should be treated according to this plan

COPPICE FORESTS

Definition.

Most leaf-bearing and a few coniferous trees have the power to coppice, after cutting from the roots or stock, and on this capacity the coppice treatment is based The power of reproduction varies in the different deciduous species, and also with the age of the tree. In a young or growing tree it is developed most powerfully, and is lost again in old age. Some species of trees reproduce only from the stock left above ground; others reproduce from the roots as well. The latter will nearly always re-coppice throughout the entire period of their existence, whereas the former coppice only for a certain time.

Sun, light and heat are absolutely necessary for reproduction *In spring, as soon as the sap in the roots begins* to move, it must necessarily ooze out of the cut, but under the influence of sun and heat it will soon dry up and form a crust in the upper portions of the cut stem The still-moving sap, charged with the material for the formation of wood, searches for an outlet, and forms buds and branches on the sides of the stock. This is the reason why in an open position the power of coppicing is more strongly developed than under shade, and also more strongly in a hot dry country than in a mild, moist climate Rich soil will increase the power of coppicing; poor soil, on the contrary, reduces it until it disappears entirely

Trees best adapted for the coppice treatment are those which possess the power of reproducing from the stock and the roots. The *time* of cutting exercises much influence on the reproduction, but this fact has, up to the present, been quietly ignored in this country. The best time is during the early spring, just before the leaves begin to sprout, and when the sap is moving.

The length of rotation depends on the species of trees; but if it be unduly prolonged, it is always to be apprehended that the trees will lose the power of coppicing. Experience has proved that coppice forests, though the returns are quicker, yield never the same amount of wood on the same area and during the same period as a high forest.

Rules for Coppice Forests.

(1) The forest must be divided into compartments, ensuring an easy and harmless removal of the cut wood. The protection against winds must also be kept in view.

(2) The trees should be felled close to the roots, and the cut must have a slanting direction, so that no water can collect on its surface. Neither the wood nor the bark of the stock must be split or torn, and it is therefore necessary to use the very best and sharpest instruments If the stocks are very old, and have often coppiced, the bark becomes hard and impenetrable. In such case some of the new wood must be left standing.

(3) The felling should be executed in early spring, and the wood removed at once into the lines of export.

(4) All areas under reproduction must be closed against grazing, and all blanks filled up by artificial cultivation

Zizyphus nummularia and other small shrubs should not be destroyed or cut till the better species of wood have reproduced themselves

COPPICE UNDER STANDARD

Description.

The name itself explains that this is a combination of high forest and coppice forest treatment. The standard trees are grown from seed, the low forest under them is coppiced from the roots, and the reproduction depends

partly on seed and partly on coppicing. I will endeavour to explain what we understand under a complete "Coppice under Standard Treatment" by showing how such a forest is produced

The forest is cut down to the roots when the trees retain still their coppicing power A number of trees judiciously dispersed over the area are allowed to remain standing. These trees increase during the next rotation of coppice, when some of them are utilized and new shoots are allowed to grow up in their stead. At the end of the third coppice rotation, a crop of coppice wood and standard trees of three different ages will be found on the ground, the oldest trees being three times the age of the coppice rotation.

General Condition

This treatment requires a good, active, deep and moist soil, or the standard trees will not attain perfection, and the soil will deteriorate

Purpose of this Treatment

We adopt this treatment for the purpose of obtaining a quick return of fire-wood bark for tanning, &c, and to grow simultaneously timber trees on the same area As said above, the trees, after they have been cut down for a considerable time, lose their power of coppicing When this happens, the seed shed by the standard trees ensures a natural reproduction, which we could not obtain in a clear coppice forest.

Influence of Standard Trees on Coppice

The beneficial influence of the standard trees on the coppice lasts a short time only, some species of trees derive no benefit whatsoever from them As soon as the young trees can dispense with protection, it becomes obnoxious to them Only those coppices, however, which grow right under the crown of the standard trees are materially affected, as the deprivation of dew and rain checks their growth The shade thrown on the young plants in an opened-out forest is not so hurtful to them as we imagine, as it changes continually with the position of the sun.

The soil under standard trees will be found dryer than amongst the surrounding coppice, and the plants below them are therefore more or less deprived of one of their principal nutriments, which tends to retard their growth. This is of less consequence in irrigated or inundated forests than in those depending solely on natural rainfall, as shade alone is only then hurtful when it is dense and continuous. A moderate shade prevents evaporation, and is rather beneficial than otherwise.

From the foregoing it may be concluded that standard trees with short stems and a strong formation of branches are more hurtful to the growth of coppices than trees with thin crowns and high stems

The following is a list of some species of trees, chosen with a view to their relative value as standard trees. I begin with the names of trees capable of affording a slight and beneficial protection, and end with those which, by reason of their dense crowns, impede the descent of dew and rain:—

Pinus longifolia	*Acacia modesta.*
Acacia arabica	*Acacia leucophlea.*
Alnus.	*Dalbergia sissü.*
Tamarix orientalis	*Abies smithiana.*
Acacia stipulata.	*Cedrus deodara.*
Acacia speciosa.	*Quercus sp.*
Acacia læta.	*Cedrela túna.*

The last-named trees, having a thick foliage, suffer less from protection overhead during their infancy than trees with thin foliage.

These are the disadvantages connected with the treatment under discussion. We must now weigh its advantages. The stocks, as they lose their power of coppicing, are replaced by plants raised from naturally-shed seed. The coppice by covering the ground protects it from drying up, and further improves it by the shedding of its leaves, thus benefiting the standard trees which again shade the soil after the cutting of the coppice. The standard trees rarely obtain the same height as if they had been raised in a high forest; but as they enjoy an unlimited amount of light and air, they produce nearly always

a larger amount of wood, and frequently of a superior quality A forest under this treatment requires less assistance by means of artificial cultivation than under clear coppice treatment. The coppice under standard treatment facilitates also the fostering of the superior species of trees, and can easily be changed into high forest treatment.

Selection of Standard Trees

The most valuable species of wood are selected or raised for standard trees. In the plains I should always prefer *Acacia Arabica* and *Dalbergia sissú;* in the hills, *Pinus longifolia* and *Kukar.* On places where deodar, oaks, walnut trees, and the other high-hill pines grow, I would leave the coppice forest treatment quite out of the question In such localities this manner of reproduction is, as a rule, unnecessary, and there is no market whatever for the small produce, except perhaps within the immediate vicinity of hill sanitaria

Length of Rotation

The length of rotation for the coppice is subjected to the same rules mentioned under simple coppice treatment, that for the standard trees depends on the size of the material we wish to produce. In the plains of this province, the usual periods for coppice cutting vary from ten to fifteen years, and three or four of such periods will suffice to produce a strong timber tree of either *Kikar* or *Sissú.*

In the lower hills, the time of rotation must be longer, and a *Pinus longifolia* standard tree requires at least four or five rotations of twenty years each to attain the size of a good timber tree

Number of Standard Trees per Acre

It is impossible to fix a theory for this thoroughly practical question, which depends entirely on the fertility of the soil, the amount of moisture in the ground, the formation of the species in general, as well as that of individual trees. A general rule, however, should be followed. At the end of a coppice rotation, not more than one-third of the should be under the immediate cover of the crowns

standard trees. The standard trees of the more recent periods must exceed the old ones in numbers.

I give here an example for 1 acre before and after cutting :—

Coppice, 15 years Old	32 standard trees, 30 years old	16 standard trees, 45 years old	8 standard trees, 60 years old	Before cutting
No coppice	32 standard trees, 15 years old	16 standard trees 32 years old	8 standard trees, 45 years old	After cutting

Rules for Reproduction.

The standard trees to be felled are cut simultaneously with the coppice and at the time of the year mentioned under coppice treatment. The cutting and removing of all material must be executed as rapidly as possible, and the area must be clear when the leaves sprout. The selection of standard trees for the last period is the most difficult task connected with this treatment, and a mistake once made is irreparable. It is therefore advisable to select and mark twice or three times the number of standard trees required, and to make a second selection from these trees after the cutting has been completed. Trees grown from seed should be selected in preference, and if they are not to be had, coppice of young stocks may be chosen. The strongest trees should invariably be selected, but an equal distribution over the area must always remain the first consideration

Standard trees with very large and low branches may be pruned with advantage. If it is found that the natural reproduction by seed is not sufficient to supply standard trees for the next rotation, the species chosen for standard trees must be artificially cultivated by means of transplants.

CHAPTER III.

TREATMENT OF FORESTS AND SINGLE TREES.

Definition.

We promote and guide the growth of forests and single trees by means of "stopping, thinning and pruning." This is called "Treatment of Forests."

Promotion of the Growth of Young Forests by establishing a Close Growth, otherwise called "Stopping."

I mentioned in the preceding chapter that a reproduced forest must be made to close overhead as rapidly as possible, the branches must touch each other, and the soil underneath must be in perpetual shade. If the young forest does not close within a short time, weeds spring up, the soil loses its nourishing power, and if it has been originally of an inferior quality, the young forest will waste away (see Tera Plantation) If this has occurred, the cultivation of corn, potatoes, or cotton between the sickening trees will have a beneficial effect on them, provided the soil be clear and not overgrown with weeds. A small quantity of earth is heaped round the stock of the ailing trees, and if they be of a deciduous nature, and have stopped growing, they must be cut off close above the ground. The new shoot from the roots will, for the greater part, prove more vigorous than the already-diseased plant. Scissors should be used for cutting down small plants, as the roots are likely to be torn or loosened if a knife, and especially a blunt one, is used. The cultivation of crops between the young growth is only practicable in forests of a regular character, planted in lines or squares.

Should the soil in a young forest get covered with weeds, they must be speedily exterminated to prevent its deterioration. The following is the most effectual and the cheapest way to get rid of them The upper layer of soil is pared of at a distance of 2 to 4 feet from the

plants, and turned over on top of the weed cover in the immediate vicinity of the sickening seedlings, so that the weed-covered side of the sod rests on the weeds close to the stem. The covered and the covering weed will decompose and form a humus close to the roots of the ailing plant. In this manner we not only neutralize the pernicious effects of the weeds, but utilize them for the nourishment of the seedlings. Plantations grown in a regular form are again the only forests in which we are able to execute this plan on a large scale. When such dangerous weeds as *Saccharum* and *Salsola* have taken possession of a soil intended for a forest, the quickest and easiest remedy, in my opinion, is to dig up all the weeds with the roots, burn them on the ground, and recultivate wherever we find blanks or weedy plants.

A deteriorating soil may be improved and a weak young growth saved by closing a forest quickly, by means of interplanting and intersowing hardier and quicker-growing species of trees.

Plants specially adapted for the soil under treatment should be selected. If we have the slightest reason to apprehend that the forest will not grow close enough, we must have recourse to an early intermixture of quick-growing trees, as they will soon protect the soil against the influence of the sun

Beneficial Effect of Undergrowth on Old Forests.

We often find, especially in this country, forests of old trees of such irregular growth and so far dispersed as to be unable to protect the soil against the influence of the climate and sun. The natural result is a gradual deterioration of the soil which renders reproduction or cultivation more difficult. An immediate clear cutting and recultivation of the most valuable species of tree would seem to be indicated here, but there are many reasons against such a course. If the trees forming the forest are not mature and in the years of their best growth, it would certainly be unwise to cut them, the irregular forest may be only in patches, or we may have such an amount of irregular old forests that it would be impossible to utilize and reproduce

them all at once. This last-named drawback prevails in our province, and an attempt to reproduce our irregular old forests at once would lead to the greatest fluctuation in the timber market (which is always a sign of mismanagement somewhere). If, on account of one of the above-named reasons, we have to preserve an irregular forest, all exposed portions of the soil should be covered as quickly as possible. Of course, the more valuable trees should be planted or sown in preference, but only when there is a certain prospect of success; if not, we must be satisfied with inferior trees —even bushes are preferable to a grass blank. A rapid improvement in the soil will soon be apparent; the humus which had already disappeared will re-form, the old trees will grow with renewed vigor, and the future reproduction will be comparatively easy.

Protection of Single Trees against the Drying-up of the Soil.

Young trees standing alone along road-sides and canals suffer even more than young forests or compact plantations from the drying-up and consequent deterioration of the soil The trees standing alone are deprived of their mutual protection, and the excessive dryness of the soil is apt to kill them if they have been recently planted, before their roots have taken firm hold of the soil, and are still unable to extract the smallest amount of moisture.

There are three courses open to us to prevent the drying-up of the soil—by watering, by covering the ground, or by disturbing its surface. In dry districts (3rd class districts) like Multán, Montgomery, the south of the Lahore District, Sirsa, Jhang, Hissar and Rohtak, trees of the more valuable descriptions cannot be grown without at least two years' watering. In other districts (2nd class districts) with about 20 inches of rainfall, one year's watering will be found sufficient, and covering the soil round the stems will accelerate their growth in the following year. Next come the districts (1st class districts) with 25 inches and upward of rainfall, including all hill districts and those lying at the foot of the Himalayas. In dry seasons an occasional watering may be required in these districts, but covering

the soil and disturbing its surface will be found sufficient under ordinary circumstances.

When canal water and the necessary fall are obtainable, we have only to run a drain along the foot of the trees. Plots near wells may also be watered by means of a Persian wheel and small nallahs; but in avenues, and where the trees are otherwise dispersed, the only way is to have them watered by bhistis or *pakhdls*. The frequency and amount of such watering depends on the permeability of the soil and the degree of heat, but a good watering twice a week will be found sufficient even during the most intense heat. The evening is the best time for watering. If possible, the covering of the ground should always be combined with the watering. The evaporation will be less rapid, and a weekly watering will then be quite sufficient.

The covering of the ground round isolated trees is of the greatest importance, and even the growth of well-established and strong trees can be accelerated by this means. On light and sandy soil this method is of the utmost utility, but may be found useful on soils of every description. Dry leaves and grasses or weeds are deposited all round the trees about 3 inches deep, and fixed with small branches of Malla (*Zizyphus nummalaria*) or Jhau (*Tamarix Gallica*), or Kothi (*Indigofera heterantha*), or any other small bush procurable. This cover not only impedes the evaporation and prevents the drying-up of the soil, but also checks the growth of dangerous weeds, and by its decomposition yields material for the nutrition of the tree. It is advisable to open out these covers for some time during the winter months to prevent mice and rats taking up their abode in them, and to expose the insects and larvæ, which are always found in them, to the cold and frost, and thus kill them

The third method consists in turning up the surface soil round the tree with a shovel or hoe, and then crumple it up This has to be done about 2 inches deep These 2 inches of loose soil will of course dry up almost immediately, but the connection between the dry pulverized earth and the lower soil is interrupted, and serves as a protection against the direct influence of the sun. This proceeding,

however, is not without its disadvantages Dust storms often carry away the loose soil, and the operation has to be repeated after each shower of rain, which re-establishes the former connection of the soil. On very binding and hard soil, especially if combined with cover, it yields the most excellent results.

Protection against the Rays of the Sun.

Young trees grown in a nursery under the shade of mature trees, or even under a thatched roof, are necessarily affected by the unchecked rays of the sun when transplanted into an open position The soft bark of their stems hardens suddenly, loses its elasticity, and stops the growth of the trees by impeding the circulation of the sap This is called "hide-bound." To prevent this we must diminish the evaporation through the bark of the stem till the tree has got firm hold of the soil and becomes accustomed to the different conditions of existence. The usual way is to wrap straw round the trunk; but insects almost invariably take up their quarters in this covering, and destroy the bark we try to protect. It is a sufficient protection to apply a layer of lime and clay soil to the stem The mixture should consist of three parts of lime and one part of clay. It will be found cohesive enough to resist the action of the rain. *Eucalyptus* and all such trees as are decidedly affected by the sun and dry heat, should have this mixture applied to their stems immediately after being planted.

Protection against Accidents.

Trees along roads and canals are naturally subjected to frequent accidents; their branches are eaten off by cattle, or their bark is loosened from the stem The protection against *mischief*, such as tearing of branches for fodder, &c, cannot be discussed in this chapter, but will be treated in another pamphlet—"Protective Administration of Forests." At present we have only to do with the protection against *bonâ fide* accidents. The orthodox Indian mud-wall circles, *if provided with air and drainage holes*, answer the purpose exceedingly well; and if a few handsful of dry leaves and grass are thrown into the encl ure

they will keep the moisture for a long time, and a good soil will form near the roots of the trees. They must be made large enough to prevent cattle reaching any portion of the young tree. Their appearance is certainly not very elegant, but they can be replaced on station roads and "malls" by a sort of crate made of bamboo or any other wood The best protection for trees on station roads are continuous fences and hedges. The former may consist of either simple posts and rails, or wire fencings, or stone walls. If the fences are made of wood, a green thorn hedge, which will look well and save the renewal of the wooden railings, should be cultivated. Hedges should always be *planted*, and the ordinary precautions already mentioned in the chapter of artificial cultivation must be observed Trees or shrubs provided with thorns should always be chosen for protective hedges in preference to others, and we could not find better material than Jand, Rerú, and Phulái for the Punjáb plains. The best and safest method is to raise the hedge on a ditch, drawn from 2 to 3 feet deep, with very gradually sloping banks. The young plants are put in in four parallel lines at a distance of 8 to 12 inches In the second year the branches must be interwoven and the top shoots cut off, and in the third year the hedge will be impenetrable. *Cactus Indica*, *Aloe perfoliata*, *Agave Americana*, &c., will make good protective hedges

Thinning.

One square foot of ground is enough for a young plant, whereas 200 square feet are hardly sufficient for a mature tree; thus upwards of 40,000 trees have to perish before a completely-stocked acre of young growth has reached maturity. An incessant struggle for light and air is therefore the inevitable consequence of the progressing growth. The plants are so dense that they cannot throw out side branches, and their whole vigour is expended in the increase of height. The stronger plants naturally grow quickest, and as soon as they have outstripped their less robust neighbours, they extend in breadth over the heads of the smaller trees. The newly-formed side branches soon encounter those of other vigorous trees, and form a cover

above the heads of the more backward growth, which consequently dies from want of light and moisture, and decomposes. But the struggle is again renewed as the space *becomes too limited for all the trees which now occupy the* ground, and does not cease until they attain their full growth. The lower branches of the predominant trees die off when their new-forming higher crowns close overhead and withdraw the influence of light and moisture. This process of extermination proceeds in a young forest rapidly, and excites a vigorous growth in height; but after a certain age, when the trees have increased in bulk and strength, they are not so quickly stifled A forest left altogether to its own resources expends much of its vigour in this perpetual struggle. We therefore must thin out.

Definition of the term "Thinning."

Thinning consists in cutting out all suppressed trees, or such weak ones which would soon be suppressed if left on the ground. We thin with a view to accelerate the growth of the trees left standing

General Rules.

The seedlings grow often so close together (especially in artificial sowings) that the evil effects thereof exhibit themselves in the earliest stages of the growth, which slackens perceptibly. To obviate this mischief, the superfluous plants should gradually be removed, that is to say, as soon as the seedlings begin to impede each other. It is decidedly wrong to wait till they show signs of ill health, as many plants are quite unable to outgrow the damages sustained in their youth. The plants to be thinned may be dug out for transplants, or be cut down to the ground with the knife or scissors. They should be cut in the beginning of the summer after the first spring growth is over. If this is neglected, and they are cut too early, the more vigorous coppices will renew the struggle with the trees left on the ground. The operation should proceed as gradually as possible, and always with the necessary precaution not to allow weeds to take possession of the soil. Artificial sowings o irrigated land frequently require thinnings in the second y

On sailába land they need not be undertaken before the third or fourth year. Natural reproduction requires but rarely such early thinnings, and artificial planting never. The second thinning we may be called to execute consists in the removal of inferior trees and coppice growth with a view of fostering seedlings of a superior description. As a rule, we must thin in such a manner as to give the better species of trees the necessary amount of air and light without interrupting the cover overhead. An inferior tree, or one grown from coppice, even should it top a tree of a superior species, should be cut down, provided the latter has vigour enough to recover, and the removal does not cause a blank in the forest. This kind of thinning must also be done carefully and gradually, for the worst tree is better than a blank, and we can only gain our purpose (to foster one species in preference to another) by repeated and continuous cuttings. A quicker covering of the soil may be counted upon if the trees to be cut down possess the power of coppicing, in which case we may thin more vigorously. Spring is again the right time for this cutting. The remaining trees, having obtained an increased amount of light and air, will rapidly spread during the same season, whereas the coppice from the stocks will be less vigorous than if the trees had been cut in winter. The young forest has by this time grown into a thicket, and the struggle for existence begins in real earnest. We must now thin with a view to accelerate the growth of the forest. The first and principal rule here is not to disturb the connection of the crowns overhead, and we must therefore only remove suppressed and badly-growing trees. However severe the thinnings may have been, the longest branches of the neighbouring trees ought still to touch each other with their tops; and if the thinning has been lenient, they may be allowed to remain interlaced some 2 feet.

Severe thinnings are admissible—

1. On good soil, in a mild and moist climate, on north and west positions.
2. When the ravages of snow or wind are to be apprehended (an early thinning with a view to strengthen the formation of branches and roots is required here).

3. For trees requiring an open position *(Pinus longifolia)*.
4. During the earlier stage of the forest, as long as the trees grow vigorously in height.
5. Where fuel is the only kind of wood we purpose to grow.

Lenient thinnings are advisable—

1 On bad, poor soil, where everything depends on an efficient cover of the ground, in a rough climate and a south position.
2 In a dry climate.
3 For shade-loving trees *(Cedrus deodara)*
4. When the trees have nearly attained the normal height.
5 On exposed places in the forests near the open country.
6. When we propose growing high timber.
7. In incomplete and irregular forests near blanks or in plots of trees.
8. If the first thinning has been made so late that the trees have had time to grow lanky.

A too sudden and severe thinning exposes the trees to all the inclemencies of the climate. Browne, in his "Forester," reckons it equal to the removal of a few degrees north, and there is no doubt that an injudicious thinning can ruin irretrievably a forest grown on a poor soil The sudden exposure causes the bark to lose its elasticity, the circulation of the sap is impeded, and the tree becomes "hide-bound." Omitting the thinning altogether is still more hur[illegible] The trees grow up [illegible] easily knocked ove[illegible] e trees in a pine forest have been allowed to grow up into weedy, thin poles, no recovery is possible. One of the first considerations when we thin a forest is the equal distribution of the remaining trees over the entire area. In a young forest we can only depart from this routine in a case of diseas trees Trees grown from coppice should always be cu preference to those grown from seed. It depends en

on the growth of the forest at what time the thinning should be repeated. The most natural way would be to cut out every year the trees which have been overtopped. But there are reasons why this is not feasible: labor and material would be dispersed over the whole forest, and supervision would be rendered difficult, if not impossible. A periodical repetition of the thinning (as soon as a considerable quantity of suppressed trees are found) must replace the annual cutting out. It is immaterial at what season the thinning of old or hill forests is undertaken, but not so as regards the younger forests in the plains, especially those on irrigated land They are in full, active life, and are still growing when night frosts begin to set in. The thinning renders them susceptible to the vicissitudes of the climate, and many of the trees freeze down to the ground. I had a warning example of this at Changa Manga Plantation, where I lost a whole compartment by one injudicious thinning. A Forest Ranger accustomed to the work should mark the trees to be thinned, and the workmen employed should be strictly supervised. As the forest grows up, we must expect to encounter more difficulty in the selection of trees to be thinned out; they increase in size, and the number we have to select from diminishes These latter selections should always be made by European officers, at least until we have trained natives The material must be brought at once to the roads and slides, and should be sold and removed as soon as possible, or burnt, if we have no sale for it, to prevent insects breeding in it. A few stacks left inadvertently at Changa Manga were found to be alive with insects of the *Bostrichus* species.

Pruning and Lopping.

I quote here an abstract of Professor Lindley's "Theory and Practice of Horticulture," which I found in Browne's "Forester":—

"The quantity of timber that a tree forms, the amount and quality of its secretions, the brilliancy of its colours, the size of its flowers, and, in short, its whole beauty, depend upon the action of its branches and leaves, and their healthiness. The object of the pruner is to diminish

the number of leaves and branches, whence it may be at once understood how delicate are the operations he has to practise, and how thorough a knowledge he ought to possess of all the laws which regulate the action of the organs of vegetation. If well directed, pruning is one of the most useful, and, if ill directed, it is amongst the most mischievous operations that can take place upon a plant. The object of pruning is either to influence the production of flowers and fruit or to augment the quantity of timber.

"Pruning is nothing less than the removal of leaves. To cut off a branch in summer is evidently so; and if the branch is naked, still its removal is the destruction of the part from which leaves would have been produced had it been permitted to remain

"'Prune not at all' should therefore be the maxim of the Forester. 'Plant thickly, thin constantly, stop carefully, and leave the rest to nature' But unfortunately it does not happen that he who plants well always thins constantly, it is still more rare that stopping is thought of, and so a maxim, one of the soundest in the whole system of Forestry, cannot be observed Hence pruning may be regarded as a necessary evil, to which the wise must submit because of the ignorant, the careful to cure the evils inflicted by the careless"

Lopping in Forests

I fully endorse Dr Lindley's maxim, but do not follow his reasoning why a systematically worked forest, supervised by an intelligent European or trained native officer, should not be carefully replenished and judiciously thinned. Forests ought and must be raised in such a way that the trees can get rid of the lower branches of their own accord (so to say *prune* themselves), and grow stems as tall as their species will allow. Only in rare instances is lopping admissible in a forest Some of these instances have already been mentioned under natural reproduction Trees may be lopped to encourage the young growth beneath them; but probably in this case their early removal has already been contemplated, and we may cut

without reference to the future well-being of the trees. If the removal of a tree would create too considerable a blank, the branches may be lopped during any of the cuttings for reproduction, provided circumstances require it. Young standard trees in coppice may be lopped, with the double view of encouraging the coppice and of promoting their growth in height. These loppings, however, have to be carefully executed. Pine trees must only be lopped when absolute necessity compels us to do so for the reproduction of forests which have to be kept intact for protection against avalanches and storms.

Pruning at the time of transplanting has already been discussed in the chapter on "Artificial Cultivation."

Lopping of Single Trees.

Single trees along canals or avenues or in fields do not enjoy the same advantages which predisposes a tree grown in a compact forest to form a tall and valuable timber trunk. The lower branches derive as much benefit from light and moisture as the crown, and their growth remains unchecked. They absorb a great amount of sap, which in a forest would have accelerated the growth of the trunk in height; and in the same proportion as these side branches increase in size, the growth in height decreases. The result of this unchecked open growth is a division into side branches at a very inconsiderable height above ground; these divide again into smaller branches and twigs, and form a low broad crown. Such trees are only fit for firewood; they impede the passage of vehicles on roads, and throw an undue amount of shade in fields. Much, therefore, as I deprecate the process of lopping or pruning in a forest, I think it necessary to guide the growth of single trees by means of judicious pruning or lopping, in order to give them a suitable formation of trunk and crown.

LOPPING.

General Rules to be observed.

Late lopping is quite as pernicious as bad lopping. The best time to begin is during the first year, after a tree has

taken possession of the ground and grows vigorously. The growth of the plant is then easily guided by the removal of few and small branches and twigs, whereas, if we retard the period of lopping, it will be necessary to cut numerous and larger branches. This is always hurtful, as by the removal of such bulky branches large wounds are inflicted on the trunk of the tree, and much of its future value as timber is thereby lost. It often happens that the soft alburnum of the young plant thus severely wounded is affected by atmospheric influences before the wound has had time to heal, causing cancers and other diseases. Still we must not lop too early, before the trees have well taken possession of the new ground, which is indicated by a vigorous growth.

I have shown in Part 1st, when treating of the Physiology and Anatomy of plants, that new leaves cause the formation of new roots; we must therefore not deprive the newly-planted tree of its leaves, or else we obstruct its first development; thence it follows that the lopping should never take place before the second year of planting.

It is quite impossible to guide the growth of trees after they have reached a certain age and have ceased to grow in height. To deprive such a tree of its branches is simply a way of slowly killing it, besides ruining the wood for any useful purpose.

Choice of Branches to be lopped.

If all branches are lopped off, a tree as shown in *Fig. 17* will be the result. Numbers of such trees may be seen in all our hills, where *Grewia elastica*, oaks, &c., are annually submitted to this process for the sake of fodder. The stem is covered with nodes, and young shoots abound round the scars of the old wounds. The wood is only fit for fuel.

A too severe lopping, by which I mean the cutting of all lateral branches, leaving only the top ones, must always prove disastrous. The tree grows slowly in circumference, and the trunk gets covered with nodes and young shoots. A too lenient cutting, on the contrary, will cause the trunk to increase in bulk below the strong lateral

branches, and to decrease in circumference immediately above them in proportion to the strength of the branches. As it is our purpose to grow trees of the greatest possible height and circumference, we must take the middle course between the two just-described methods. If we concentrate the greatest amount of leaves above the middle of the height of a tree, we divide the derivable advantages equally between the growth in height and bulk It may therefore be considered a general rule to lop all branches which are situated on the lower half of the tree (*see Fig. 18*).

Under certain circumstances, however, some of the branches forming the crown must also be lopped or shortened.

If two branches forming the top of the tree struggle for superiority, the less vigorous of the two must be cut back, as shown in *Fig. 19*, or the trunk will divide here, or at least grow an unsighty elbow.

Exceptionally strong branches have to be cut back (*see Fig. 19*), or they will lead to the formation of elbows and other deformities in the trunk, and absorb an undue amount of sap as they grow stronger. If they are not kept back early, they will have to be cut subsequently, and the severe wound will be dangerous to the well-being of the tree.

When two branches grow out of the same place, as shown in *Fig. 20*, one has to be removed as early as possible. If this is not done at once, the future pruning of such a double branch will hardly be possible on account of the size of the wound the lopping would necessitate For the same reason we have to cut some of the branches which sometimes grow in a circle round a tree as soon as they make their appearance (*see Fig. 21*) They must be cut sooner or later, and delay would only cause a number of considerable wounds close together, which would surely tend to the formation of nodes, or even cancers

Young branches consisting as yet only of green unformed wood must not be entirely pruned, but only cut back. If we were to cut them entirely, the half-formed tissue would soon be affected by the atmosphere, and deformities and cancers would be the result. If, on the other hand, by

by means of this precaution to protect the bark and sapwood against lacerations (*see Fig. 26*). All pruning and lopping should be executed with good, sharp and steeled instruments, and not with the ordinary iron country hatchet. Small twigs on young plants should be cut with a pruning knife or pruning scissors; larger branches with either handsaw or light hatchet; but the former is less dangerous in unpractised hands, and should therefore be preferred in this country.

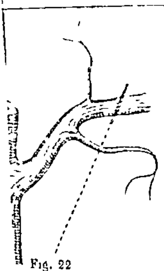
Should we be forced, in spite of all care, to inflict large and dangerous wounds, we must protect them against moisture by covering them with a mixture of pitch and resin till they are completely healed. This is made just warm enough to be liquid when applied a few days after the cutting, and after the surface of the wound has slightly dried up.

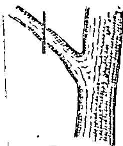
Season for Lopping.

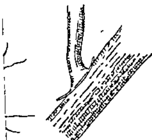
The circulation of the sap is partially interrupted through the lopping of branches; we must therefore take heed at what season we undertake the operation. We may lop either at the end of winter or the end of summer. Each time has its advocate. If we prune in winter, the wounds will be exposed for a shorter time before healing; but if the lopping takes place at the end of the summer, before the annual growth is quite finished, we deprive the tree of less nourishing sap (see Physiology of Plants), and a smaller number of new shoots will form round the wounds.

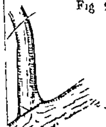
Removal of new Shoots called Water-Shoots.

The vital action of the tree causes a great quantity of wood-forming sap to collect in the vicinity of the wounds, and the consequence is frequently a formation of numerous buds and new shoots. These have to be removed as soon as they have grown a few inches in length and before they have had time to form wood, or else much sap will be lost, and their removal at a subsequent time will cause the formation of nodes.


Fig. 22


Fig. 23


Fig 24



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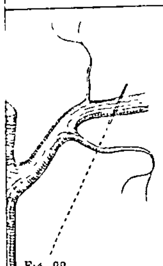
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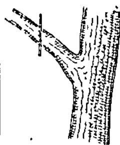
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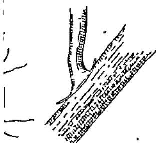
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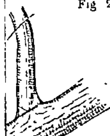
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Fig. 22


Fig 23


Fig 24



Frequency of Lopping.

A lenient and therefore frequent pruning is always preferable to a few but severe operations. Much vital power is expended in the formation of large branches which are cut away during severe lopping. This power, if properly husbanded by means of lenient cuttings, might be directed towards the formation of a more bulky trunk. The removal of large branches not only causes large and more hurtful wounds, but it destroys the necessary balance in the vegetation.

The physiology of plants teaches us that large roots form on the same side of the tree on which we find large branches, and if the latter are suddenly removed, the functions of the corresponding roots are suspended. It may often be observed that after the removal of a large branch, the tree ceases to increase in bulk on the side from which the branch has been removed. It takes years to re-establish the balance in the process of vegetation, and it is only possible to restore it entirely by means of a severe re-action and the formation of other large branches, which have again to be lopped. The vital force is, so to say, thrown backwards and forwards by injudicious pruning, causing every time the formation of new elbows, distortions, and cancers. The only means to prevent such revolutions in the growth of a tree consist in an annual, or at least bi-annual, pruning of small branches.

When the trees have accomplished their first vigorous growth in height, we must prune at longer intervals, and the operation must cease altogether before the trees have reached their total height. In a province like the Punjab, exhibiting so many modifications of climate, the length of these periods varies considerably. On rich, irrigated soils in the Plains their duration is short, and in the Hills it is longer. On poor soil we must not prune at all.

Fig. 27 is a drawing of a Sissú tree five years old and about 18 feet high, grown on a rich, moist soil. This sketch shows how we have to prune under all the conditions of growth enumerated in the foregoing paras. All the dotted branches must be removed.

Formation of a new top of a Tree.

In spite of all precautions, it may happen that the top of a tree standing along a road-side is eaten off by cattle, or destroyed by some other accident. If this happens, the strongest side branch near the top should be selected, placed in an upright position, and tied to the stump of the old top, as shown in *Fig. 28.*

The growth of the other neighbouring branches is arrested by cutting them back The young branch will soon form into a new stem, and when a year or two afterwards the old stump is amputated, the wound will soon heal

CHAPTER IV.

Cultivation, Reproduction and Treatment of Punjab Trees.

In the preceding pages I laid down the general principles of artificial cultivation, natural reproduction, and treatment of forests and district plantations. I now proceed to discuss the more important trees of this Province in detail, with a view of showing how far the rules enumerated above may be applied to them. It is, however, impossible to describe the cultivation, &c., of every tree worth planting in this Province, and I have therefore restricted myself to those which have proved a success. The trees follow each other according to their importance, and not, as in my Botanical Pamphlet, according to natural orders.

I divide them into—

1st.—Trees growing in the plains and lower hills up to 4,000 feet.

2nd.—Trees belonging to mountainous regions.

The former I sub-divide again into—

a.—Trees requiring fresh and good soil.

b.—Trees growing on arid and dry soil

1 *a*.—*Dalbergia Sissú.*
Acacia Arabica
„ *elata*
„ *speciosa.*
„ *stipulata.*
Cedrela toona
Morus alba
Zizyphus jujuba
Salix babylonica and *Salix tetrasperma.*

These trees are as useful for district arboriculture as they are for forest cultivation; whereas the following are only adapted for road-side planting and wells and topes:—

Azidirachta Indica.
Melia azedarach

Zizygium jambolanum.
Mangifera Indica.
Tamarindus Indica.
Ficus Indica and *religiosa.*

1 *b.*—For arid soils the most useful trees are—

Acacia modesta.
„ *leucophlea.*
Prosopis spicigera.
Tamarix orientalis

2 In the hills, the cultivation of *Cedrus deodara* is the most important, and next to it that of *Pinus longifolia* I must also mention the cultivation of *Pinus excelsa, Abies Smithiana* and *Picea Webbiana.*

The most important deciduous trees are the *Quercus* and *Acer* species, the *Juglans regia, Pavia Indica, Pistacia integerrima.*

Dalbergia Sissú.

This tree, already described in my Botanical Pamphlet, seems to prefer the moister climate in the immediate vicinity of the great rivers where it grows spontaneously.

General Habits of the Sissú as regards Soil.

The tree shows, in an uncultivated state, a preference for a light and even sandy soil, and grows freely in the Káchi, near Miánwálí, on the Indus, on almost pure river sand, and may also be found on sandy islands in all rivers from Oudh to the Indus. I have not changed my opinion since writing my first memorandum on plantations in the Punjab, namely, that a very stiff soil does not suit the nature of the tree, and that it is useless to attempt its cultivation on a clay soil, or if an impenetrable strata of clay or kankar is deposited close below the surface of the soil. In proof thereof I give the adjoining sketches and measurements taken by myself from trees dug out of our different plantations.

Fig 29 gives an accurate representation of a young Sissú grown at Ludiánah on a sandy loam (half sailába), and *Fig. 30* one of the same size grown on very stiff clay soil at Rodesháh, near Lahore

These are only examples, but serve to show the character which the tree assumes in different soils.

It is a sure indication of unsuitable soil when a young tree inclines to grow like *Fig. 31*.

The character of roots, as exemplified in the Nawshera plantation on the Biás, which is a sailába soil, may now be noticed.

The trees here form a tap-root, which in most cases is of very great length, only sending out side roots at 1½' to 2' below the surface. The same formation is noticed at Jugián on the Rávi, only there are more side roots.

We find a similar formation of roots on the sandy soil of Jálandhar, where the moisture lies more than a foot below the surface; but I am sorry to say that in this case I can only give the figures taken from one specimen, (*see Fig 32*).

Fig 33 shows the formation on the sandy loam of Ludiánah, and *Fig. 34* that on the sandy loam of Phillour.

The stiff and very stiff soils of Nág, eleven miles from Amritsar, Rodesháh, and Tera, show a formation more or less inclined to keep all the secondary branch roots on the surface, according to the degree of stiffness of the soil (*see Figs. 35* and *36*).

The specimens were taken from the stiffest and average soil in the worst part of Rodesháh.

Tera shows more or less the same form, and it is therefore unnecessary to give other figures—

Tree.	Root
8' 8"	2' 3"
6' 6"	2' 6"

Fig. 37 is a representation of the growth in Sarái Amánat Khán Plantation This is the stiffest kind of soil we have attempted to cultivate.

Two curious formations are shown in *Figs. 38* and *39*.

Fig. 38 is a tree grown in Tera, the root of which had originally penetrated the kankar, but afterwards died off below the strata. The tree was 12' 4" high, and the remaining living root only 1' 2".

Fig. 39 was grown at Nág on a well-watered, heavy but rich soil with impenetrable sub-soil

Figs 40 and *41* show the growth on Changa Manga.

The influence of the water-supply can to a great extent be determined by examining the formation of the roots

In Tera, which is dependent on natural rain-fall or artificial watering, the trees procure their supply of moisture more from the surface, and have accordingly the secondary side roots higher up the main root than those which have to go deeper down for their nourishment, and are dependent on percolation from below.

The Sissú trees at Rodesháh and Tera, now five, six and eight years old, die whenever the roots touch the impenetrable strata after one or two years' sickening. The following are the first outward signs of decline the young tree exhibits: the top branches grow together in form of a broom; the leaves curl up and feel dry to the touch; the bark has a dried up appearance and peels off from the cambium The roots, when dug up, show deformities and signs of dry decay. A small *Bostrichus* attacks the diseased tree, only few leaves re-appear in spring, and the tree lives but rarely through the third year. Watering does not cure the disease; it only changes its character, and we observe a decomposition of the sap instead of dry rot. The leaves of the apparently healthy trees turn suddenly yellow; the bark round the lower parts of the trunk begin to detach itself; the skin of the roots when dug up can easily be removed with the finger; and a pungent smell may be perceived when they are cut through Soon after these symptoms have set in, fungi begins to grow on the roots and on the lower portions of the trunk, and the tree dies within a short time. The disease has been watched in all its stages at Changa Manga, where it attacked two compartments. These two compartments have a stiffer loam soil than the rest; they are low and much overgrown with Saccharum. We were able to combat the disease by stopping the irrigation, and by cutting down the Saccharum and allowing a free circulation of air. I have never observed either of the two above-described diseases on trees grown in a light sandy loam or sand soil. Extreme poverty of a light soil is only indicated by a slow and stunted growth, but not by the destruction of the organism of the tree

Sissú will grow on any soil, provided it has the necessary degree of looseness—soil with salt efflorescence [illegible] excepted. The tree grows equally well on sand (Kachh on the Indus), loamy sand (Jugiin on the Rávi), sandy loam (Ludhiánah Plantation and Meerut), and loam (the Changa Manga Plantation), provided the soil is fresh and contains sub-soil moisture. This moisture in the sub-soil is of greater importance than rain-fall. At the Ludhiánah Plantation we have a strong percolation of water, and we observe here a more vigorous growth of young Sissú than at Ambálah, though the soil is poorer and the average rain-fall less.

Stagnant moisture, especially in heavy soil, is hurtful to the tree. The Sissú decidedly requires much air and light in its maturity, and must have room for its branches to develope a strong timber trunk; but the seed germinates readily in the shade of the parent tree, and the young plant grows well for some time under cover.

[illegible]

to [illegible]

in some compartments at Changa Manga.

Artificial Cultivation of Sissú

The tree can be cultivated either by sowing, planting, or setting of cuttings.

The seed ripens in December and January, and may be preserved without difficulty till the end of the rains, which is the best period for sowing. If the seed is quite ripe, the pods are smooth and of a dark straw colour, the grains fill the pod, and, when cut through, they will be found to be of a greenish white colour. It is, however, well to test the percentage of productive seed. The seed should be taken out of the bags in which it has been brought and spread out in seed boxes. Turn it over twice a week with a wooden shovel; this is sufficient to prevent heating, and it may keep good even if this is not done at all.

The Sissú develops its long tap-root [illegible] feet long, which has to be cut if the seedlings are transplanted; this undoubtedly checks the growth of the plant, which depends to a great extent [illegible] the light soil.

cultivate on strips. This method is more economical, requires less seed, receives protection from the weeds between the strips, and the seed is not so liable to be laid bare by winds.

The cheapest way is to draw 3 to 4 plough furrows close together, then leave a space of some 5 feet, and begin again with the furrows. The seed is dibbled in and pressed down after being slightly covered with soil. The furrows should be ready before the beginning of the rains, and the seed should be sown as soon as possible after the first rain-fall, as all plants raised from seed sown in the beginning of the rains are found to be several inches higher and more regular than those sown at a later period If the ground is liable to be flooded, the same precaution must be taken as mentioned under broadcast sowings.

The grass, especially if it be short *"dhúb"* grass, should not be sold or removed for the first year of cultivation. The price realized would not compensate for the damage done to the young plants. If the land is overgrown with high grasses of the Saccharum species, which must be removed, the furrows should be made by coolies. But land so overgrown is nearly always of a poor description, and a cultivation by sowing is not quite certain to succeed. Two-thirds of a maund of seed per acre will be required. The cultivation of seed places is the least expensive method, as already described in Chapter I. The amount of seed required will be only one-third of a maund.

We may cultivate in trenches on land depending on rain-fall alone This is, however, a costly manner, and should only be made use of in exceptionable cases—for instance, when a layer of hard binding clay 12 to 18 inches th overlies the moist, loose soil of sailába land This must be broken through by digging trenches a foot The original soil is left in the trenches, mixed wi loose sub-soil, which will enable the young plants their roots into the moist soil below, and to tak footing. The strata must be thoroughly broken an incomplete penetration is waste of money. sown with the hand and lightly covered with time of sowing is during the rains, and the amo

required is half a maund per acre But wherever planting material is procurable, we should transplant.

Cultivation of Sowing Nurseries.

Sissú nurseries are, of course, only wanted when young planting material is not otherwise procurable. On active and fresh sailába, planting material can be grown without going to the expense of making a nursery; and where cultivation on the ridge and artificial irrigation are in vogue, a sufficient number of seedlings of a good description can be got from the ridges.

For cultivation which depends on rain-fall, or cultivation on higher sailába, where the plants depend partly on rain-fall and partly on percolation, nurseries are indispensable. They are also wanted for road-side, well and grove planting The soil has to be dug 12 inches deep and prepared carefully, as described in the general remarks on artificial cultivation. The seed which has to be sown in March can either be sown broadcast in lines a foot or 18 inches apart, or on ridges a foot or 18 inches apart. The distance of lines and ridges depends on the length of time we intend to leave the seedlings in the nursery. Wells have to be used for watering the land. If the water is far below the surface, we must work Persian wheels with bullocks; but a tread-wheel worked by a coolie is cheaper, provided the water is near. The seedlings are fit for transplanting in the rains of the same year, but can serve for winter transplants or rain transplants in the following year. Road-side transplants should be allowed to remain in the nursery till the second winter. Their roots should be cut down in the second spring to about 9 inches long by a few digs with a sharp spade. This will facilitate the transplanting and ensure success (see Chapter I)

Transplanting.

The Sissú bears transplanting well with or without earth, according to circumstances

The tree must be in rest, that is to say, it must not be in leaf, and the soil must be moist to allow transplanting

without earth It succeeds best on very fresh sailába or on irrigated land, and with young plants without side-shoots to their roots The most favorable time for planting on sailába is during the winter rains, and on irrigated land, during January and February.

It is executed, as described in Chapter I, on previously-watered soil. The utmost care must be taken to fix the whole length of the root with loose soil in such a way as to establish the plant firmly. The seedlings must be watered in early spring, and it will be found that they grow more rapidly than the seedlings of the same age which were never moved.

With proper watering hardly a plant is lost in this way. I would recommend this exceedingly economical method for the cultivation of Sissú round wells The distance must be 5 feet apart in the lines.

On sailába land holes must be dug about a foot diameter and 18 inches deep. The plants are placed therein, and fixed with loose soil, as described in the chapter, "General remarks on artificial cultivation." Plants of a year and half old are preferable to younger ones on such soil. The best distance is 5 feet quincunx.

Transplanting with earth may be executed either during the rains or in winter. On irrigated land the planting of Sissú with the earth is waste of money; but for road-side planting, or when the land is entirely depending on rain-fall and dew, it is the only cultivation from which a certain success can be expected.

The process of transplanting with earth is the same with all trees, and has already been discussed in Chapter I The best distance is 5 feet quincunx.

Winter transplants are benefited by a single watering at the time of transplanting.

On sailába, or on moist light soil, a second watering is not required, but on a more binding soil and for all road-side planting the seedlings should be watered throughout the spring till the rains set in. A watering twice a week is quite sufficient. In the second spring they should, even on road-sides, be only watered when they show signs of

distress Rain transplants on road-sides should be watered throughout the following spring if the soil is dry and binding. On places where the trees require a second year's watering, and canal water is not obtainable, Kíkar should be cultivated instead of Sissú.

If the conditions of soil and moisture are the same as described in the preceding pages, the Sissú is one of the most valuable trees for the planting of road-sides, groves and grazing grounds. The shade of the trees is too intense for cultivations in fields. Though the tree can be cultivated by means of cuttings, the above-named methods are so easy, safe, and cheap, that there is no need to discuss that point.

Natural Reproduction.

As remarked somewhere else, Sissú seed will germinate under the protection of parent trees, and the young seedlings will flourish in their shade if only the soil is loose enough and sufficiently moist. This fact, and the natural reproduction of the tree on the Káchi and on the Ganges islands, furnish ample proofs that it is possible to reproduce the Sissú in a natural way as a "High Forest." The mature trees bear nearly every year a good crop of seed, which facilitates reproduction.

Dense forests, such as our plantations will be, must be thinned for the admission of light and air. The entire process of this reproduction has been described in Chapter II. After the reproduction has been completed, a few of the seed trees may be allowed to remain standing to expand into strong timber trees during the next rotation.

If the rotation is fixed on twenty years and upwards, it is advisable to dig up the roots of the felled trees, as they will have lost much of their power of coppicing. The working of the soil is an additional preparation for the reception of the seed If the forest is to be cut at a shorter rotation (for fire-wood only), the roots should be left in the ground. They will soon produce a crop of coppice; and a seedling here and there will form the new forest under the standard trees left (coppice under standard trees,

see Chapter II). On irrigated land and on fresh sailába, I recommend the first-named method with a higher rotation. On land depending on rain-fall only, the last method will be found to answer better; on such soil, and under such climatic conditions, the cutting of the forest should proceed gradually, allowing seedlings to spring up under protection against the direct influence of the sun. As soon as the ground begins to be covered with grass and weeds, the recultivation must be completed by artificial means.

The seed of the Sissú is broad and light, and cannot reach the soil through a cover of weeds and grasses; it is therefore necessary to assist with artificial cultivation as soon as such a cover begins to form.

Intermixing other Species of Trees.

On fresh sailába, the real home of the Sissú, the intermixture of any other species is unnecessary, and it will be found that, if not severely thinned out, the Sissú is apt to overgrow and suppress nearly all others, the Kíkar not excepted. Of this we have several examples. At the Government plantations, Jugián and Ludiánah, Kíkar and Sissú were cultivated together, and we find now clear Sissú forests only. The Kíkar did not die of frost, as in some of the other plantations, but was fairly choked. Jhand, Rerú, Phulái and other slower-growing trees have no chance at all on such a soil.

On a binding and irrigated soil an intermixture of other trees succeeds, and may be recommended, as it ensures a more equal covering of the ground on places not quite suited to the Sissú, and such will be found on the best of bár lands.

The trees I would propose for intermixture on irrigated land are the Jhand, Rerú, Phulái, Bér and Farásh. I recommended the intermixture of Kíkar and Mulberry only when the soil and climate suit exactly. The change of temperature in an irrigated plantation is too severe for the *Acacia Arabica*, and the tree is certain to die down to the roots. A group of trees may escape here and there,

but the dry wood of the dead trees serves as breeding places for a small, most obnoxious, and already often-mentioned insect of the genus *Bostrichus*, which attacks after a time the healthy Sissú. At Changa Manga Plantation this insect has as yet only been found in compartments which were intermixed with Kíkar, and which are in consequence annually filled with dry sticks.

The danger accruing to the rest of the forest through the intermixture of Kíkar is far greater than the advantage we would derive from it if it escaped the frost. The intermixture of the Mulberry tree should also be avoided, because it requires a severer amount of watering than the Sissú. On land depending, or partly depending, on rainfall (south of the Sutlaj), the conditions alter again. Here the Kíkar and Bér are the best trees to be intermixed. The Kíkar grows more rapidly here than the Sissú, and being satisfied with a smaller amount of water, its cultivation is less expensive.

Further treatment of Sissú Forests.

During the first four or five years no thinnings are required in Sissú forests cultivated by transplants at 5 feet apart, as the trees have enough space and draw each other up; but the thinning must begin in the second year if cultivated by means of sowings. The average scale of distance for Sissú thinnings, as calculated by me, is 2½ feet for trees from 5 to 10 feet high; 5 feet when the trees are 10 to 20 feet high; and 10 feet when above 20

The first thinnings should always be executed in spring, after the plants have sprouted, for reason already given in Chapter III. In case of natural reproduction, coppiced plants should always be cut out in preference to seedlings

Sissú trees in groves, on road-sides, and on grazing ground may be pruned with benefit to their formation and growth, but the pruning should always be done with a saw, and in accordance with the rules laid down in Chapter III.

Acacia Arabica.

The Kíkar requires a great amount of light and air, and covers a considerable area if grown in the open. It sends

its tap-roots much deeper down than the Sissú. Dr. Stewart, in his "Punjab Plants," states that he has seen the tree nowhere indigenous except in Sindh, but it grows well in the Punjab plains as far north as Ráwalpindi. The tree thrives best on a sandy loam and loamy sand; also on a sandy soil, provided it has a certain amount of subsoil moisture. On heavy loam soils too, it grows well, but only when the soil has been thoroughly worked and loosened, at least during the first youth of the tree. Abrupt changes between heat and cold are most hurtful to it.

The Kíkar germinates and grows by means of rain-fall only, but at the same time resists a flooding better than the Sissú, provided the tops of the young trees are not under water.

The *Acacia Arabica* flowers in March, and its seed ripens in June

Cultivation.

If the seed is healthy, the grains fill up the seed places in the pod, and have a round and full appearance; their colour is a shining dark brown. The seed is of a dry description; it is easily preserved in seed houses, but must be carefully guarded against mice and rats. If the seed has to be kept for the next spring's cultivation, it must be turned from time to time, as a small insect will be found to attack it (*curculio*)

The seed germinates easily under the influence of rain-water, percolation, or irrigation. Seed which has passed through goats, or has been mixed with wet manure before sowing, germinates more readily.

On irrigated land the cultivation is easy enough, sown like the Sissú on the side of the ridge. The Kíkar requires much less water after it has once germinated, but it suffers much from frost. None of our cultivations *on irrigated land* have succeeded, though all of them came up well, and reached a height of 12 feet and more; they freeze every year down to the ground, and though their roots coppice readily, and a group of trees escapes here and there, the majority succumbs at last. The cultivation requires about half a maund of seed per acre.

On sailába land, the Kíkar may be sown either on strips or seed places like the Sissú, but the seed should be covered more thickly with earth, which ought to be pressed down on it. The width, distance and manner of preparing these strips or places depend on the same external circumstances as mentioned under the general rules of artificial cultivation. Under ordinary circumstances, we sow in the beginning of the rains. The young seedling will appear above ground about 15 to 20 days after sowing, and reach in the same year a height of 18 inches to 2 feet On ground liable to be flooded, we must sow at the end of the rains for reasons explained in Chapter I The plants will soon germinate, but only reach a height of 5 to 6 inches before the cold weather sets in

The Kíkar suffers on sailába land much less from frost than on irrigated land, but it is advisable to protect the young plants through the first winter, especially those raised from seed sown during the end of the rains If the grass surrounding the seedlings is high enough, the easiest way is to tie it together above the young plants; but if the grass is too short, the best way is to take a good handful of long grass, tie the top together, and put it over the plants in the shape of a conical hat This can be done at a cost of 4 to 5 annas per acre

The grass must be taken off in the beginning of March, when the night frosts have ceased. The trees will grow 4 to 5 feet high till the next winter, and no danger from frost is then to be apprehended. Even as far south as Dehli, young Kíkar sown during the end of the rains suffer from night frost during the first winter.

Many sailába lands get muddy and slushy during the rains, and in consequence inactive. The seed will germinate, but rots at once in the soft warm mud. The sowing, in such instance, must be put off till the end of the rains. The Dehli Plantations, where such conditions of soil prevail, afforded me an opportunity of ascertaining the value of autumn sowings In the first year, we sowed during the rains, and succeeded only partly on the higher and drier parts of the plantations A portion of the

Kíkar seed, however, was left, and as we had no further use for it, we sowed in strips during the first days of September on some soft, but not muddy, soil. This succeeded admirably, and further experiments have convinced me that autumn is the right time for sowing on such land. On very light soil the Kíkar seed should be covered more thickly; little holes 2 inches deep may be pressed into the ground with the end of a stick, and the seed dropped into them. The hole is then closed by scraping soil in it *with the foot, and the earth is pressed down with the heel.* A ground only slightly covered with weeds and grasses is required for this cultivation.

On light soil the young Kíkar suffers much from the ravages of rats, which gnaw their roots. I have observed that these animals burrow along the lines of trees and cut every root as they proceed. To prevent this to some extent, I prefer sowing on seed places. The rats have then to dig through a considerable amount of soil before they reach the root of the next tree, and extensive blanks caused by them are more easily prevented.

In the more moist 1st and 2nd class districts of the Punjab plains, Kíkar germinates and flourishes *on land depending on rain-fall* without irrigation, provided the soil is fresh and contains sub-soil moisture The ground may be ploughed up, the seed sown broadcast, harrowed, and, if possible, rolled before the actual summer rains set in; strips may be ploughed up and the seed sown in lines, or places dug and sown. But with all these different methods the chief point is to press the soil well down. The Kíkar shows a natural tendency to grow on well-worked and slightly-raised ground. The best method therefore is to draw shallow trenches 6 inches deep, forming the soil into a ridge, and sow on the side of it. In our plantations, the Kíkar sown on the side of the boundary ditch show by far the most lively growth. I recommend a distance of 15 feet between these trenches, and would plant Sissú transplants at 7½ feet apart between the ridges, with a view to the future improvement of the forest soil. An unmixed Kíkar forest should be sown at 7½ feet, but such a forest hardly

produces a humus soil on account of its open growth and the inconsiderable leave-fall. Even in a closed Kíkar forest the ground is covered with grass and weeds, as may be seen in the Ludiánah Plantation.

On low ground where water is likely to collect, the raising of the soil for the seed is of special value, and here little heaps of soil 1 to 2 feet high may be thrown up and the seed sown on the top of them. As on account of its open and little shading growth, neither cerealia nor grasses suffer beneath the shade of the Kíkar, it is therefore especially adapted for cultivation in fields and on grazing grounds

Sowing in Nurseries

The same method is pursued here as with Sissú The soil is thrown up in little ridges on which the seed is sown. The young seedlings, when they have appeared above ground, must be less frequently watered than Sissú On irrigated land the seed is sown in March, and the plants will be ready in the rains; but if the seedlings are to be raised without watering, we sow during the rains and plant in the following rains. The young plants should be covered with grass during the winter months

Transplanting

It is a fallacy to believe that Kíkar cannot be transplanted I have tried it myself on a small scale at the Dehli Plantation with complete success. Transplants with the earth can be put out during the rains, as well as in the winter months, if care be taken to preserve the whole of the tap-root intact. I have observed that winter transplants benefit by being cut 2 inches above ground. A covering of these plants is under such circumstances not necessary. As yet, I am not prepared to give an opinion whether Kíkar can be transplanted without earth.

Natural Reproduction.

The Kíkar naturally reproduces itself by means of seed and coppice. All the innumerable young Kíkar we see on so many fields in this province owe their existence to

natural reproduction The seed is heavy, and falls straight down from the tree The young trees we find at a distance must therefore have been carried abroad by birds, or must have passed through animals.

As mentioned above, the soil in a clear Kíkar forest is mostly overgrown with grass, and the natural reproduction of such a forest without assistance can only be partial and slow. It will be found useful to loosen the soil after cutting a small number of trees and to scratch the seed in and cover it, thus combining artificial cultivation with natural reproduction. By this means alone we can count on a rapid reproduction If Kíkar trees are old, it will be as well to stub the roots out and to sow round the hole; this will always succeed. In young Kíkar forests, with the power of coppicing still strongly developed in their roots, the stumps may be left in the ground and cut repeatedly. If some of the old trees are kept as seed trees, and artificial means are sparingly employed, the most satisfactory reproduction may be expected. (See general rules, coppice under standard)

Further treatment of the Kíkar.

Naturally reproduced Kíkar forests will, in this province, hardly ever need an artificial thinning out. But when they are created, or artificially reproduced, they grow up very dense, and require an early thinning. I cut them in their second year to a distance of 2½ feet to 3 feet apart, and in the third year to a distance of 5 to 6 feet, and again after two years to 10 to 12 feet, at which distance they should remain till they can further be thinned for firewood.

The first thinnings, when the whole tree is overgrown with thorns, are difficult to execute. The easiest way is to cut the young plants with heavy garden scissors, and to pull them out of the lines with short iron hooks.

April and May are the months for thinning. If thinned in the cold weather, the coppice will spring up and grow as tall as the preserved trees. Where the soil is too dry for the Sissú, the Kíkar makes an admirable road-side tree.

The tree stands pruning well, but as the wounds heal slowly, the operations must be carefully performed, though

torn branches and uneven wounds do not decay rapidly on it

ACACIA ELATA—SAFÉD SIRIS

The tree is not indigenous in the Punjab, but we find it cultivated. I have constantly observed that it grows best on a light, loam soil, such as we find in the Jálandhar District, and on very old sailába. It is one of the quickest-growing trees in the Punjab plains, and as the wood is very useful, it should be largely cultivated The tree suffers from frost in the more northern parts of the Punjab plains, especially if grown on irrigated land, on heavy cold soil, or within forests. The roots of the tree are of a soft description, and kankar or clay beneath the surface of the soil destroys it

Cultivation

The seed ripens in April *On irrigated land* the seed sown on the ridge in the months of April, May, and June germinates readily. It takes about fifteen days to germinate in April, and half of that time in hotter months The *seed* requires about the same amount of watering to germinate as the Sissú, and the young *plant* a little less than the young Táli The tree grows from 5 to 7 feet in the first year, but on bár land it escapes but rarely the effects of the frost. When killed down to the root, the tree will coppice again, and in the second season some young trees may escape *On sailába*, the seed, if sown in the rains, will germinate readily, but it should be sown on old sailába only which is not liable to be inundated, the tree not having the same power of resisting floods as the *Dalbergia Sissú* and *Acacia Arabica* The tree suffers less from frosts on such lands. *On land depending on rain-fall*, the soil must be of a very superior description, either a sandy loam, or loamy sand, and must be very fresh The rain-fall too must be very considerable to secure success. The time for sowing is during the rains

Planting

The tree when grown in nurseries (which ought to be laid out, sown and treated like Sissu nurseries) can be

transplanted with earth either during the rains or in winter. Thus transplanted, the tree is especially adapted for road-side trees. On all other but very fresh soil it requires a further watering Winter transplants ought to be watered till the rains begin, and rain transplants ought to get an occasional watering till October, when the vegetation begins to rest. It depends entirely on the condition of soil if the transplants have to be watered again in the next year Single trees on the road-side do not suffer so much from frost On irrigated and moist sailába land they can be transplanted without earth, like the Sissú.

Cutting

The tree grows readily from cuttings; but as the plants grown from seed are, as a rule, stronger and healthier than those reared from cuttings, it is unnecessary to discuss this way of cultivation.

ACACIA SPECIOSA—SIRIS.

The tree grows wild in nearly all the lower hills, and we find it cultivated all through the province. Its entire *habitus* is very much the same as that of the preceding tree.

It prefers light loam soil, thrives moderately well on sandy soils, and succeeds but badly on bár land. The changes of heat and cold on uncultivated bár land are too severe for this tree, and in an irrigated Doáb plantation only a small proportion of the seedlings live through the winter.

The natural home of the tree is the Terai, where the frost is certainly severer than in the plains, but nothing like so abrupt.

Cultivation and Reproduction.

The seed ripens in January. The cultivation is the same as that of the *Acacia elata*, and like that tree the Siris is one of the best species for road-side planting

Treatment.

Both trees are very much injured by injudicious and careless lopping, which inevitably causes dry rot and encourages destructive insects to attack the tree

Acacia Stipulata—Ohi

The natural home of this tree, too, is in the Lower Himalaya. It suffers from the rapid climatic changes in the plains, especially in a bár or desert climate In Changa Manga, where it germinates readily and grows rapidly, we have not succeeded as yet to keep it alive through the winter, though there is no doubt that it grows well in better-cultivated parts of the Punjab plains, where the climate is milder.

The Ohi seems to dislike a very heavy soil The cultivation is the same as that of the two preceding trees

The three last-named trees are especially adapted for district arboriculture in the districts underlying the hills, such as Gujrát, Siálkót, Gurdáspúr, Hoshiárpúr, Kángra, Jálandhar, Ludiánah, and Ambála In Kángra, Gurdáspúr, and in some of the other districts they might be grown with advantage in forest plantations, provided good soil is selected

Cedrela toona—Tún

This handsome and useful tree is indigenous in the lower hills up to 2,000 feet It was formerly cultivated throughout the Punjab and strictly preserved; under the British rule, however, it has been greatly neglected, and there are but few good-sized trees left Within the few last years many efforts have been made to re-establish it The formation and foliage of the tree indicate that it stands a considerable amount of shade In the earlier stage of growth, the young plants not only tolerate shade, but actually require protection from the sun The frost kills them in the first year, especially in the bár and on irrigated land, but when they have attained the age of two or three years they are hardy enough to withstand the effects of the frost. The Tún requires a rich soil; but, as the more lateral growth of the roots indicates, it is not necessary that the layer of good soil should be more than a few feet deep The tree wants a good supply of water, and will grow even on an inferior soil if kept moist enough. It is very liable to the attacks of a *lepidopterous* insect, which consumes the pith of the young shoots.

Cultivation

The seed ripens in June, and the fulness of the grain indicates its healthy condition. Throughout the province the tree requires a great amount of care during the first year of its life. The young seedling wants protection against the direct rays of the sun in summer, and against frost in winter. Sowing in the open is therefore, if not impossible, at any rate impracticable, and would entail useless expenditure. Transplanting would seem to be the best and cheapest method. The transplants can be raised either in pots or in nurseries, but I find nurseries produce the better material. The best position for such a nursery is under old trees, or between two lines of Sissú, Kíkar, or Mulberry, which have not closed overhead. The soil should be a rich black humus, such as we find in old forests or old native gardens It must be well worked and cleared of roots. The seed should be sown in the beginning of June, as the spring sowings would hardly be strong enough for summer transplants, and they would grow of too large a size in the nursery to be easily protected against frost. The seed may be sown broadcast, but I prefer sowing it on small ridges on account of the watering. The seed, which must be covered lightly, will germinate after eight to ten days, and in the beginning of November the young plant will be about a foot-and-a-half high. At this time the seedlings must be covered, and remain so up to the end of February. Transplanted either in March or during the rains they will reach a height of 7 and 5 feet, respectively. On bár land, the trees must again be protected during the winter, especially if grown in a plantation. Singly, on road-sides, or fields, the tree has a greater power of resistance on account of the free circulation of air. In the third year it will be tall enough to be beyond the reach of night frosts (see Book I, Climate).

When the surface soil is not quite fresh, the Tún tree, owing to the more lateral formation of its roots, requires in nurseries, or as transplants, a greater amount of watering than the *Dalbergia Sissú*, and road-side trees must be watered another season. The tree, though valuable on road-sides, round wells, and within villages, causes great harm in fields, owing to its intense shade.

Natural Reproduction.

The seed germinates well under mature trees, and I am convinced that natural reproduction, if combined with artificial cultivation, will answer well, but it has not been tried as yet

Further Treatment

I recommend a very lenient and late thinning to prevent the tree from separating close above ground and forming branches In the open it is difficult to prune it into a high trunked timber tree, though wounds caused by lopping heal quickly

MORUS ALBA, &c.—TUT—MULBERRY

These trees are cultivated all over the Punjab plains and in the hills up to 5,000 feet The wood of good old Mulberry trees is most useful both as timber and fuel, but as they are seldom quite healthy, they produce but rarely timber of good shape On a good loam soil the Mulberry grows well and fast, not so readily on sailába, and on bár land only with considerable watering The tree wants more moisture than the *Dalbergia Sissú*, and the young plants are easily affected by drought. I have observed that they died off on heavy soil in July and August as soon as they sprung up, if not constantly watered The trees, after reaching a certain age, become diseased, especially on sailába and bár land I maintain, however, that the climate of the plains is the chief cause of their decay Careless pruning is exceedingly hurtful to this tree I recommend its cultivation in the districts underlying the hills. The clay soil of the Peshâwar valley, intermixed as it is with micaceous sand, seems to suit the nature of the tree, and we see it there healthier, though smaller, than in other parts of the Punjab plains

Cultivation

The different species of the tree ripen in May and June On irrigated land they succeed best if sown on the ridge like the Sissú Up to 20th of July they may be sown, and if well watered they will hold their own against Sissú of

earlier sowing. They require to be watered till the end of October, as even November sun is dangerous to them without a moist ground

When sown on moist sailába they will germinate, but not so well as the Sissú. Sowings will not succeed on land solely depending on rain-fall

Planting.

It is easy to raise Mulberry plants in nurseries and to transplant them, and in this respect the tree is even hardier than the Sissú. Provided the soil is moist enough, plants with half-destroyed roots will bud and grow readily. With the exception that the Mulberry nursery is sown in June or beginning of July, the preparation and treatment are the same as that of a Sissú nursery. The transplants may be put out either in the rains, or in December, January and February, and, like the Sissú, with or without earth. The tree can be grown from cuttings For road-side planting it is not of much value, as it is much affected by lopping and browsing. It gets diseased at an early age, loses its leaves by attacks of insects, and dies soon under such circumstances

ZIZYPHUS JUJUBA AND LOTUS—BERI.

This tree is useful for timber and fire-wood; the leaves are much valued as fodder for cattle, and, if grafted, the fruit is highly prized. The tree is common throughout the Punjab, though Dr. Stewart doubts its being really indigenous in this province. It grows mostly on cultivated land or on sandy loam, but not like its congener, the small scrubby *malla nummalaria*, in the hard and arid soil of the "Bár." It succeeds on a saline loam on which Sissú, Tún and Mulberry do not answer, and requires much less water than Sissú. It is nearly as hardy in this respect as the Kíkar, and at the same time suffers less from frost than this tree. On bár land, even this hardy tree freezes often down to the ground during the first winter.

Cultivation

Towards the end of May, when the fruit begins to get quite soft, the seed is ripe.

On irrigated land, the tree succeeds well if sown in June on the ridge. The seed germinates after ten to fifteen days, and the plants will attain a height of 1 to 2 feet during the first season.

On sailába, the best time for sowing is during the rains, and if the soil is loose, the seed must be sown deep. The best way is to make a hole in the ground with a stick about 2 inches deep to drop the seed in and to press the earth down on it with the heel.

Seed sown in shallow places or lines is constantly scratched up by the jackals When germinated, the seedlings will grow 8 to 12 inches high during the season, and suffer in rare instances only from frost on such lands.

If land depending on rain-fall is fresh and the rain-fall *considerable, the trees can be grown directly from seed as* on sailába land, but a safer way is to *transplant* them The seedlings are reared in nurseries watered by wells Sown in June the young plants can be transplanted in December, January, or February, or during the following rains The tree does not seem in favor for road-side cultivation, but we see it frequently near wells, in fields and near houses and villages For district arboriculture it must be reared in nurseries, if it is to be planted in unirrigated fields, or on road-sides; but for well-cultivation, or as boundary trees in irrigated fields, it must be raised from seed The tree in its varieties should be cultivated in all parts of the Punjab plains, except in the arid portions of the lower hills and such parts of the bár as cannot be irrigated.

Natural Reproduction

The tree coppices vigorously, and yields a dense shade as coppice wood. It will be of great value for coppice under standard

It can be grafted as described in the general rules of artificial cultivation.

SALIX—WILLOW.

We have as yet cultivated only two species of this tree in our plantations in the plains, *Salix babylonica* and *Salix tetrasperma*

Without irrigation they grow only on very moist sailába in the immediate vicinity of rivers; but with canal irrigation and close to ditches and water-cuts they are easily cultivated. The best time to plant the willows on irrigated land is January, February, and March, and the best way is to plant them with a peg. A hole is first made into the previously-irrigated soil 5 to 10 inches deep, and the cutting put into it, as described in the general parts of this pamphlet.

On sailába land the cuttings can be put in either in December and January, or during the beginning of the rains. Extensive willow plantations on low sailába land are the best protection against the washing away of the soil. The following is the most effectual way to make such protective plantations: a hole some 15 inches square and *12 inches deep is dug, and about eight or ten cuttings are* placed in it close to the sides Another hole of the same dimensions is dug at a distance of 3 to 4 feet, and the first hole is filled up with the earth of the second. The soil is then pressed down with the foot, care being taken not to damage the cuttings. In this way the work proceeds till the area is filled up. The best cuttings are made of wood from two to four years old On very wet soil four to six years old wood is used.

The many jhíls we have in this province should gradually be planted with willows and tamarix, and thus a great amount of useless ground would be reclaimed for arboricultural purposes. A previous drainage, especially of heavy and binding soil, is of course a great help to arboriculture, but much can be done without it by forming ridges, or little mounds, and plant on them

Salix alba and some of the other hill willows should be much more cultivated near water-courses, as it fixes and secures their banks

AZADIRACHTA INDICA—NÍM.

A tree commonly planted in the South-East of the Punjab Phillour seems the last place, North-West, where it succeeds well. At the Nág Plantation, Changa Manga, and even on milder sailába plantations, the tree dies of

frost. It prefers a loam soil, and we have not been successful on light and moist sailába soils.

Cultivation

The seed ripens in July and August

We have so many better timber and fuel trees in our province that the Ním has little interest for us as a forest tree, more so, as the other trees grow quicker, and their general *habitus*, as regards forest growth, is better adapted to the rougher climate of the Punjab. On account of its intense shade, however, and for other good qualities, the tree is worth planting on roads, near villages and wells, and in plots on grazing ground.

The easiest way is to raise the seedlings in small nurseries, and transplant them with the earth either during the rains or in December. The transplants require but little watering, and only till the beginning of the rains

MELIA AZEDARACH—BAKÁIN.

This hardier *congener* of the preceding tree flourishes in the north and north-west of our province The tree prefers a loam soil, but grows and prospers on any soil, with the exception of the unirrigated bár land

Bakáin wants less water than most of the other trees recommended for district arboriculture, and does not require as much care In a plantation or forest, the tree is considered a weed only fit to cover the ground till we have been able to cultivate other trees, but its hardy growth, its few requirements, and the luxurious shade it yields, make it a favourite tree for well-cultivation and for shady topes on grazing grounds.

Cultivation.

The seed ripens in January and February, and remains on the tree till the leaves re-appear and the new seed begins to form It may be sown in March, but must then be watered, or it can be sown during the beginning of the rains. The young plants may be transplanted either in December, January, and February, or during the rains.

As the tree is only cultivated along road-sides, wells, &c., the best way is to plant them with earth.

Sizygium Jambolanum—Jáman.

The tree is cultivated in the districts underlying the hills, and eminently adapted for well and village cultivation. It attains a large size, and the wood is far better than that of the Bakáin, or even Ním tree, though not equal to that of the Sissú and Kíkar. It yields an excellent shade, and the fruit is highly valued by the natives

The Jáman does not require a deep soil; it succeeds well on a loam soil with boulders and gravel below the surface On bár land this tree suffers from frost, like most of the inhabitants of the Terái. In the Nág Plantations the seedlings sprung up readily enough, but froze down every winter. In the plains proper of the Punjab the tree is certainly not a forest tree; but if Terái Plantations were initiated, this would be one of the trees worth selecting

Cultivation.

The seed ripens in June. For district arboriculture young plants ought to be raised in the district nurseries, and be transplanted during February with earth.

Mangifera Indica—Mangoe.

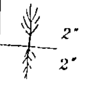
This is decidedly a tree belonging to the more southern provinces, and is apt to deteriorate in most parts of the Punjab as regards growth, fruit, and wood. The tree courts a rich, light, fresh loam soil, and a mild and even climate. Nowhere in this province can it be grown without protection against frost for at least two or three years. The natives protect and cherish this tree on account of its fruit, and the cultivation may be safely left to them. Government, however, should import grafts and establish grafting nurseries in each district.

Cultivation.

The seed ripens in June. The pulp of the fruit is removed and the seed washed in water and sown in a box

Fig. 39

Fig. 41



filled with rich soil. The seed must be well watered, and will germinate after 15 to 20 days. In September the plants are put out singly, and should be watered every two or three days. In the beginning of November the young plant must be covered with grass to protect it against frost. This cover is removed in the beginning of March, and the tree must again be watered till the rains set in, and covered again through the winter. The following February the tree ought to be grafted or budded, which has been described under the general remarks on arboriculture

TAMARINDUS INDICA—IMLI.

This tree is really an inhabitant of the more southern parts of India, and can only be cultivated successfully in the Dehli, Ambálah, Karnál, and Multán Districts

Cultivation.

The tree must be raised in small well-protected and watered nurseries, covered during the winter months, and transplanted with the earth during February

FICUS INDICA—BÓR

This tree is cultivated throughout the Punjab plains, and, when once established, is satisfied with nearly any descriptions of land

Cultivation.

The Bór is easily grown from cuttings, which are planted in July It is necessary to water them after the rains cease till the beginning of the cold weather Cuttings of 8 to 10 feet length will take root Another way is to plant out in the rains the natural seedlings which are found in abundance near old trees, and which have mostly been planted by birds

It is difficult to raise young plants in nurseries and not worth the trouble, as natural-grown planting material can be got in abundance

FICUS RELIGIOSA—PIPAL

This tree is found cultivated over the entire Punjab plains, and, like the Bór, is valuable as a shade-giving tree near tanks and rest-places

Cultivation.

Like the *Ficus Indica* it is cultivated by means of naturally-grown seedlings, and can be reproduced by cuttings, but they are less certain of success than the *Ficus Indica*. The time for both ways of cultivation is during the rains.

ACACIA MODESTA—PHULÁI.

The tree is indigenous in the Salt Range and in all the low hills east of the Satlaj. In an uncultivated state it prefers a rocky and arid soil, but it grows well on canal embankments in the bár In its natural state it has hardly ever had a fair chance of growing into a tree, as throughout the rakhs where it is found it has been constantly cut and broken down, or browsed by camels, goats and cattle. There are, however, good-sized trees near Jhelam in the Tilla and Pubbi Rakhs, and in the Nág Plantation all along the canal embankments The tree flowers in June, and the seed ripens by the end of December and in January.

Cultivation.

The seed, when ripe and healthy, has a greenish-brown, polished appearance. It is a dry seed, and its germinating qualities are easily preserved It must be carefully guarded against rats and mice; but its greatest enemy is a little grey insect, a species of *curculio*. When these insects have once got into the seed, they destroy great quantities of it in a short time.

On irrigated land the tree grows but slow Dr. Stewart mentions in his "Punjab Plants" a tree in the Sahāranpúr gardens, about 30 years old, which has only 5½ feet girth by 30 feet height. On account of this slow growth it would be an unremunerative speculation to raise unmixed forests of it on land requiring a considerable outlay for watering; but sown on the ridge intermixed with Sissú and other trees, it affords a greater security to the cultivation, especially on the more arid and binding places. We have largely intermixed it at Changa Manga Plantation. In rakhs, which can only be occasionally watered, the tree sown on seed places or on strips will be found to answer well, and

still more so if intermixed with Jhand, Rerú, and Farásh The best time for sowing is March and April

On sailába the tree is after a very short time suppressed by the quicker-growing Sissú and Kíkar, and it is not worth while to cultivate it.

If land depending on rain-fall is of a superior quality, where Sissú and Kíkar can be grown, it would not pay us to sow Phulái, but as it is one of the few trees capable of re-stocking arid and rocky lands with a forest, and improves the soil for the cultivation of the quicker-growing species of trees, we must not neglect its culture On such arid land the soil should be worked in deep seed places, and the seed must be well stamped down in the beginning of the summer rains, which should be abundant to enable the seed to germinate The entire Pubbi Range, near Jhelam, and all the low arid hills of the Pesháwar, Ráwalpindi, and other districts at the foot of the Himalaya, might be re-stocked with forests, if Phulái were carefully cultivated.

Planting

The tree when transplanted young succeeds well on fresh soil, but I am not prepared to state how it would succeed on arid land. Experiments must teach us this, as well as the best time for transplanting I believe the summer rains to be the most favorable time, and would certainly recommend that nurseries of this tree be made, for, as a rule, planting succeeds better on arid and poor soils than sowing Even on the most arid soil a portion of the seedlings are sure to succeed if mixed with Rerú and Jhand. The cultivation ought to be repeated till a portion of the land is under cover; and when this is accomplished, the next area should be taken in hand The cultivation and re-stocking of the arid lower hills mentioned above is one of the most important arboricultural questions, and should be taken in hand as soon as the more pressing plantations for the supply of Railway fuel are finished.

Natural Reproduction

The Phulái will coppice readily when cut down; and as it coppices from the roots as well as from the stock, this

way of reproduction will last for a long time. For treatment of the coppice forest, as well as time of cutting, see general rules in Chapter II.

Our coppice rakhs under present conditions are, without exception, ruined by rights and grazing I believe that any one of them situated on tolerably good soil would grow in 50 years into a dense forest if shut up against grazing, grass-cutting, and other uses and misuses. To accelerate reproduction and to shorten this period, we must combine artificial with natural reproduction

ACACIA LEUCOPHLAEA—RERÚ.

This tree grows like the Phulái in the more arid parts of the Punjab plains, but prefers the eastern portion of the province Like the preceding tree it is but rarely allowed to reach its natural size, being browsed down by camels and goats The largest trees are found in the vicinity of canals or other water.

Cultivation.

The seed ripens in April and May; it is of a greenish brown color, and has a polished appearance when ripe. Being a dry seed, it keeps its germinating power for years, but is very liable to the attacks of insects, which destroy large quantities of it if we do not take the utmost precaution.

The manner and season of cultivation are precisely the same as described for the *Acacia modesta.* Like the former tree it produces freely by means of coppicing, and is as useful for the recultivation of our arid rakhs as the Phulái for the re-stocking of the lower hills

PROSOPIS SPICIGERA—JHAND.

This is another of the modest children of the soil. It prefers a dry bár land, and sends its roots deep down in search of water. I have followed the roots of a Jhand tree in rakh Changa Manga to the depth of about 60 feet. It is lopped and browsed down more than any other tree I know; and only its great vital power enables it to resist this ill-treatment and reproduce

I understand that Méla Rám, the great Fuel Contractor, causes the roots of all the trees in the extensive private rakhs between Mián Mír and Okárá to be stubbed out, and it remains to be seen if he will succeed in exterminating even the long-suffering Jhand and Karíl Whenever the tree is left undisturbed it grows to a considerable height. It is one of the very few trees able to penetrate a soil mixed with kankar

Cultivation.

The seed ripens in June, and is easily preserved if protected against mice, rats and insects

On irrigated soil it germinates readily, and may be sown any time during the summer, but here we cultivate it only as an intermixture in plantations It does not suffer from frost, and covers the soil.

On sailába land it thrives; but there is no necessity for its cultivation

On lands depending on rain-fall the tree grows without difficulty, and the cultivation is the same as that of Rerú and Phulái.

Natural Reproduction.

In no other useful tree is the power of coppicing more strongly developed than in the Jhand, and "coppice treatment," aided by artificial cultivation, is the best way to reproduce it.

TAMARIX ORIENTALIS—FARÁSH

This tree grows throughout the Punjab plains from Delhi to Peshávar and Multán. Its growth is rapid, and it attains a considerable size. It prefers a loamy soil, but is also found on hard clay soil and on sand.

The Farásh grows a thick tap-root, is very hardy, and does not seem to suffer from either frost, drought, or excessive moisture. I have seen it growing in the Montgomery bár, on sailába land on the Rávi, on swampy soil near jhíls, and on saline "kallar" land.

Cultivation and Reproduction.

The seed ripens in January; it is very small and downy, and for this reason difficult to collect. As soon as it is

way of reproduction will last for a long time. For treatment of the coppice forest, as well as time of cutting, see general rules in Chapter II.

Our coppice rakhs under present conditions are, without exception, ruined by rights and grazing. I believe that any one of them situated on tolerably good soil would grow in 50 years into a dense forest if shut up against grazing, grass-cutting, and other uses and misuses. To accelerate reproduction and to shorten this period, we must combine artificial with natural reproduction.

Acacia Leucophlaea—Rerú.

This tree grows like the Phulái in the more arid parts of the Punjab plains, but prefers the eastern portion of the province. Like the preceding tree it is but rarely allowed to reach its natural size, being browsed down by camels and goats. The largest trees are found in the vicinity of canals or other water.

Cultivation.

The seed ripens in April and May; it is of a greenish brown color, and has a polished appearance when ripe. Being a dry seed, it keeps its germinating power for years, but is very liable to the attacks of insects, which destroy large quantities of it if we do not take the utmost precaution.

The manner and season of cultivation are precisely the same as described for the *Acacia modesta.* Like the former tree it produces freely by means of coppicing, and is as useful for the recultivation of our arid rakhs as the Phulái for the re-stocking of the lower hills

Prosopis Spicigera—Jhand

This is another of the modest children of the soil. It prefers a dry, bár land, and sends its roots deep down in search of water. I have followed the roots of a Jhand tree in rakh Changa Manga to the depth of about 60 feet. It is lopped and browsed down more than any other tree I know; and only its great vital power enables it to resist this ill-treatment and reproduce

Natural reproduction by means of seed as light as that of the Farásh, can never be completely successful. Young trees will only spring up on entirely protected places, and numberless seedlings may be found on one spot and none on another. It is therefore always advisable to combine the natural reproductión with artificial cultivation Much can, however, be done by digging trenches at right angles to the direction of the winds prevailing during the winter rains, wherever Farásh trees are found. The seed will be caught in these nullahs, germinate, and blanks may be filled up during the following rains from the abundant seedlings.

CEDRUS DEODARA—DIAR.

This splendid tree, already described in the Botanical Pamphlet, grows in all our Punjab hills from 4,000 to 9,000 feet. It prefers a well decomposed gneiss or lime-stone soil, and, though it grows on the steepest and [illegible] slopes, flourishes best on old levelled fields. The [illegible] hibits a decided preference for the north and west [illegible] of the hills, and only on the highest elevations above [illegible] feet changes to the south and east side.

The young plant thrives best on a rich brown [illegible] soil, and succeeds but indifferently when the soil [illegible] and dry. Many of the failures of our artificial [illegible] are mainly due to the fact that we disregarded [illegible] and tried to cultivate the tree on a ruined soil [illegible] lings grown on the rich humus soil of a forest, [illegible] the protection of their parent trees. The Deodar [illegible] only a very thin layer of good soil, and [illegible] always near the surface. In a natural forest the [illegible] plant in its fourth year reach rarely deeper [illegible] foot or 18 inches.

I give here sketches taken in the forest [illegible] tree from its first to its third year, together [illegible] surement (*see Fig. 42*)

Reproduction and Cultivation

The seed ripens in November, and germinates [illegible] a good humus soil The young plant [illegible] of mature trees, and natural reprodu[illegible]

Forest treatment" is preferable to any other cultivation in complete and pure Deodár forests. Some of our hill forests have reproduced themselves exceedingly well, even though suffering under the disadvantage of an irregular treatment.

In Chapter II, I have already described the general rules applicable to a High Forest treatment. All cuttings must be lenient, and particular care must be taken to keep the weeds down, as the growth of the Deodár is slow during the first five to six years. In a mature Deodár forest the ground is usually thickly covered with moss and a layer of undecomposed leaves and humus. A preliminary cutting is required before the seedlings can strike root. The cutting for germination must be lenient, as the seed germinates as soon as a little light has been let into the forest The Forester must now carefully watch the forest under reproduction. The trees must again be thinned two years after the seedlings show above ground, or they will disappear, weeds will take their place, and the reproduction becomes uncertain without artificial assistance.

When once sufficient air and light is admitted, the forest may be left to rest for some time without harm being done to the young growth; but it must be cut to the ground as soon as the seedlings have reached a height of 4 to 6 feet. On good fresh soil, and in a moist climate, the parent trees may be cut down as soon as a young thicket begins to form, but on poor soil we should cut them down at different times, allowing the forest a rest to recover the damage inflicted on the young growth. The Deodár outgrows quickly any injuries, and is therefore especially adapted for High Forest reproduction The young Deodár grows well if protected sideways against the direct influence of the sun It is, however, a great risk to reproduce without artificial cultivation by means of small, narrow, clear cuttings protected against the *South* by the mature forest, as in most cases weeds and bushes will spring up and stifle the irregular young growth Regular Deodár forests are, however, of rare occurrence, and the cutting by selection, as it has been carried out in this country, with a view to the easiest transport only, has caused the greatest irregularities The young Deodár, though it may have been

for years under dense shade, recovers and grows into a healthy tree. Small thickets, therefore, grown in perfect shade may remain, and will be valuable for the next rotation The general rules for the treatment of such irregular forests are already given in Chapter II. Netural reproduction in forests of this description depends altogether on the susceptibility of the soil. When the ground is overgrown with a cover of thick grass or weeds, it is impossible to re-stock the forest by natural reproduction.

For the treatment of mixed forests, the general rules in Chapter II will again serve as a guide. The Deodár is found intermixed with *Pinus Excelsa*, *Abies Smithiana*, and *Picea Webbiana*. Weeds are less dangerous to the reproduction of a forest of such description. The manner of cutting is the same as for pure Deodár forest, whereby the *Pinus Excelsa* and the *Abies Smithiana*, which require more light than the Deodár, are kept back. The Deodár, of course, being the most valuable tree, is kept as a seed tree, and the young growth of the other species is cut down wherever it impedes the growth of young Deodár. When such a forest nears maturity, it should assume by degrees the character of a pure Deodár forest.

Artificial Cultivation

When the soil in a pure or mixed Deodár forest becomes overgrown with weeds and grasses, or when we intend to create a Deodár forest, we must have recourse to artificial cultivation

In a forest under reproduction, the ground should be worked in places or strips wherever the soil, owing to the presence of weeds or grasses, is unfit for the reception of seed Seeds may be scratched into such places and covered Sowings in the open will only succeed if the soil is still a fresh, brown humus, or real forest soil. The best and most natural time for sowings is during autumn Wherever the soil is of an inferior description, we must have recourse to planting.

The nursery plant is under all conditions to be preferred to the natural seedlings, as it is by far the hardiest, and does not require the same amount of protection The

forest plant is quite useless for open positions if not artificially protected against sun and frost. The best age for transplanting is in the third year, when the plants have reached a height of 12 to 18 inches. They can be transplanted either during November, or March and April Rain transplants will also succeed.

The greatest care must be taken not to injure the tips of the tender roots when the seedling is taken out, transported, or planted. It can be transplanted either with or without earth. The best distance for an unmixed Deodár plantation is 3 feet (horizontal measurement), but this distance may be greater if, on account of the scarcity of Deodár plants, seedlings of *Abies Smithiana* and *Picea Webbiana* are intermixed.

If we cultivate deteriorated soils, or more so grass blanks, the young plants must be manured A few handfuls of good humus will often secure the whole success of a cultivation. The plants will also benefit by a protection overhead. Shrubs are tied together and put over them in form of an inverted *kilta*. This protection should be put on when the rains cease, and removed the following spring.

Nurseries.

A nursery should be on a rich soil of decomposed gneiss or lime-stone intermixed with humus. In Chapter I, the fullest instructions for the establishment of nurseries will be found. The soil must be worked 12 to 18 inches deep, hoéd, raked, and, if necessary, manured.

The seed may be sown either in autumn or spring; but as the preservation of the exceedingly oily seed is very difficult, autumn sowings are, as a rule, preferred. The seed should be sown in drills about 12 inches apart The sowing board should be used for this purpose. Success will be more certain if the nursery beds are covered with moss and branches till the next spring.

General Remarks.

All efforts should be made to grow the Deodár nearer our markets, close to the river banks, and on hills nearer the plains The Deodár will thrive at a much lower eleva-

tion than we find it now, though for physiological reasons I doubt if the timber would turn out so well.

In Abbottábád a number of Deodara were planted five years ago by Captain Ommanny, one of the best and most active district arboriculturists, and they are now 12 feet high, and grow rapidly.

PINUS EXCELSA.

This tree, next to the Deodár, is the best timber tree in our Himalayas, and thrives from 5,000 to 11,000 feet. It grows to a considerable size, prefers good forest soil, but thrives, even as a young plant, on worse soil than the Deodár. We do not often find the tree in pure forests, but mixed with *Cedrus Deodara*, *Abies Smithiana*, and *Picea Webbiana*.

Natural Reproduction.

When the tree is intermixed with Deodár, we must cut as though we had to deal with a pure Deodár forest; but in pure *Pinus Excelsa* forests, or where it is intermixed with *Picea Webbiana* and *Abies Smithiana*, the cuttings must be more severe, as the seedling requires a greater amount of light than the young Deodár.

Artificial Cultivation.

The seed ripens in autumn, and can be preserved in the cone.

It may be sown in the open, on strips, or places, but requires a good humus soil, and will succeed whether sown in autumn or spring. The safer method, however, is to transplant seedlings reared in a nursery. They are not so susceptible to the evil effects of an exposed position, but the same precautions must be taken as with Deodár planting.

Pinus Excelsa nurseries are treated exactly like those of Deodár. It should never be artificially cultivated as a pure forest, but as an intermixture of Deodár, planted at 6 feet quincunx, it is very valuable. All these intermixtures will end, of course, in a nearly pure Deodár forest.

ABIES SMITHIANA.

This tree grows in most parts of the Punjab Himalaya between 5,000 and 10,000 feet. It attains a large size, and though it is at present not highly valued, will, without doubt, yield excellent timber when impregnated. It thrives best on a humus soil, but is satisfied with a poorer soil, and reproduces naturally in clumps even on deteriorated soil and grass blanks. For this reason it is the best tree to re-stock ruined forest ground by intermixing it with the artificial Deodár cultivation.

Natural Reproduction.

The rules are the same as for the Deodár. Only the cutting must be more severe, as the young plant does not stand the same amount of shade We must, however, bear in mind that in a mixed forest the cuttings must be executed to suit the requirements of the Deodár.

Artificial Cultivation.

The seed ripens in autumn, but remains for some time in the cone, in which it may be preserved if the cone is picked before the seed has fallen out.

Sowings can be executed in spring or in autumn on good, rich forest soil. Like the Deodár it should be grown in nurseries, and transplanted during the spring or autumn Transplants out of the forest are hardier than those of the Deodár; but as we cultivate the *Abies Smithiana* only artificially, as a protection for the Deodár on inferior soil and exposed positions, nursery plants are preferable.

PICEA WEBBIANA.

This tree grows all over our Punjab Himalaya from 5,500 to 10,000 feet. We find it in pure forests and intermixed with *Abies Smithiana*, near the highest belt of arboreous vegetation. The wood is not without value as timber, but will improve by impregnation.

Natural Reproduction

The cuttings for reproduction may be more lenient than the *Abies Smithiana* cuttings, and the young seedlings require as much shade as those of the Deodár.

Artificial Cultivation.

If the same precautions are observed as with the Deodár, the cultivation is sure to succeed The natural seedling stands transplanting better than that of the Cedar. In all higher altitudes the intermixture of this tree is advisable for the protection of the Deodár.

PINUS LONGIFOLIA.

This pine is satisfied with the poorest soil It grows all through the Siwaliks from 2,000 to 6,000 feet. Its timber has the greatest carrying power of all the Punjab conifers, the roots yield tar and turpentine; it has the great advantage to grow nearer our markets than any other hill tree. I am convinced that this tree will yield the greatest net money return when we once begin to impregnate with kreosotic fluids. Satisfied with very poor soil, its open and wide-spread growth does not tend to improve the soil; and fires which occur frequently and spread rapidly over the ground covered with dry resinous leaves and twigs, destroy often the little humus which has formed.

Natural Reproduction and Artificial Cultivation

The *Pinus longifolia* forest reproduces from seed if only strictly guarded against cattle, and more so against fires. An abundance of flowers indicate a seed-year, 14 months before the seed ripens. The forest on the area to be reproduced should then be cut down, with the exception of some eight or ten good, healthy seed trees per acre.

Before the shedding of seed in April, all bushes should be dug out, all stocks removed, as well as plots of suppressed young growth, which, unlike the Deodár, never recovers The soil should be worked on seed places with hoe and rake. These severe cuttings should only be executed when a seed-year is expected. Should this fail, for some unforeseen reason, seed must be sown over the area before the rains set in. It ripens in October, but the cones only open in April and May. The best time to collect seed is to pick the cones from December till March. Really *good* seed-years are rare, but there is no doubt that the constant occurrence of such failures is due to the frequ-

forest fires and other misuses of the forest. After the cones have been gathered, they must be put under shelter till April or May. The cone is then exposed to the sun till it opens, and the seed is shaken out. The cone is then pressed in a cone-cracker made of wood, in the shape of a big nut-cracker, with handles 3 to 4 feet long, one of which is fixed to the ground. The seed which did not all fall out of the cone of its own accord is then picked out. The clean seed has to be kept in a cool, airy place to prevent heating.

The seed must be sown either in the beginning of March, when it will germinate during the spring rains, or before the rains begin. The spring sowing often dries up in the hot months of May and June. The seed is but thinly covered with earth, even on the lightest soil not more than ¼ of an inch. Nurseries are laid out on somewhat poor humus soil, and the ground is prepared not more than 12 inches deep, and the seed is sown in March or in the beginning of the rains. Twenty-five seers of seed are required per acre.

The seedlings can be transplanted as yearlings or as plants two years old; but to ensure success they must be planted with the earth around their roots.

Amongst all our coniferous trees the Chîl alone grows a tap-root in its early youth, and care must be taken not to injure it when the seedling is taken out, which is best done with the hollow spade. The season for transplanting is during the spring or beginning of rains, and the correct distance is 4 feet apart.

DECIDUOUS HILL TREES.

Lately I have had no opportunity of studying artificial cultivation, reproduction and treatment of the deciduous trees indigenous to the hills, but I would recommend as the safest plan to raise them in nurseries on good humus soil, and to transplant them into the open according to the general rules given in Chapter I. Their description is to be found in the Botanical Pamphlet, but their natural reproduction is as yet of little interest to us.

The most important are *Juglans regia* and *Pistacia integerrima*. Their timber makes the most beautiful furniture

wood, and would command a high price. They should be largely cultivated in forests. The walnut tree grows in the Himalayas from 5,000 to 10,000 feet, and is easily cultivated. The nurseries should be sown in spring on account of the mice, who devour the seed during winter The seed is put into pots and mixed with sand. The pots or gharahs are closed with a piece of wood and buried under ground. In April, the seeds are sown about 4½ inches from each other in drills, and covered 2 inches deep with soil After the lapse of a year the seedling is taken out, its tap-root is shortened, and it is put in a planting nursery Two years later it can be transplanted into the open On account of the expense, I would only plant it 15 feet apart amongst other trees

Juglans regia, the Canadian walnut, yields the best timber of all walnut species, and it would be worth while to import some seed.

The *Pistacia integine*, "*Kakar*," grows in our hills between 1,500 and 5,000 feet, and should be largely cultivated

Next in value comes the *Fraxinus*. It grows from 4,000 to 18,500 feet, and I recommend its cultivation. It thrives, however, only on the best description of soil.

Acer and *Ulmus*, too, should be intermixed, and the artificial cultivation of oak trees, especially of *Quercus incana* and *Quercus ilex*, will facilitate the recultivation of arid grass blanks with the Deodár. The safest method is transplanting, and the re-stocking of such arid places is well worth the outlay.

Nurseries should be sown in March, and seedlings put in planting nurseries 18 months later, and the tap-root be cut at the same time After a lapse of two years they can be transplanted into the open Under favorable conditions a dibbling of seed in prepared places will succeed

Foreign Trees.

As regards foreign trees, the best method is always to sow the seeds in boxes filled with a mild, rich forest soil, and to water them with watering pots, till they have reached the height of about 2 inches They are then separated and planted into single pots, and put out into the open on places well manured with humus

As a rule, forest plants prefer a light, loam soil; poor or binding soils must be enriched or loosened with humus or ashes.

Gmelina arborea can be grown in the plains, but must be protected against frost.

Some species of *Eucalyptus* will, with care, grow in the plains, but their roots and stock must be protected against the hot-weather sun. They grow better if richly manured with ashes, or even animal manure. If the soil is binding, it must be loosened round the stem. On good, moist soil, just below, or in the low hills, they grow rapidly without these precautions.

Castanea vera should be grown on a good fresh humus soil in the hills and in a sheltered position. The young seedlings must for years be protected against frost. If once established, the tree is easily contented as regards soil.

Casuarina grows well in the plains on light soil.
